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JANSKY & BAILEY BROADCAST—TELEVISION DEPARTMENT

PENNSYLVANIA EDUCATIONAL TELEVISION

FINAL REPORT TO THE
GOVERNOR'S ADVISORY COMMITTEE

JANUARY 3, 1968

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JANSKY & BAILEY BROADCAST-TEL·EVISION DEPARTMENT

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FINAL REPORT TO THE GOVERNOR'S ADVISORY COMMITTEE

January 3, 1968

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ATLANTIC RESEARCH CORPORATION

PENNSYLVANIA EDUCATIONAL TELEVISION

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Introduction

The Governor's Advisory Committee on Public Television has retained the engineering services of Jansky & Bailey for technical studies relating to the development of the proposed Pennsylvania Educational Television Network. This final report to the Committee completes the engineering considerations, design concepts, and recommendations for the Committee's consideration.

Scope of Present Engineering Studies

These engineering and technical studies on behalf of the Governor's Advisory Committee have concentrated on determining the system requirements, gathering pertinent factual data, and evolving a system concept together with various relevant alternatives. Cost estimates are "order of magnitude" based on other similar systems now operating. Supplemental background, supportive and informational material of a technical nature have been prepared for the Committee for use in its final report to the Governor.

Further engineering designs and liaison effort will be needed after the Committee has made its recommendations to the Governor. Exploratory negotiations, now under way with common carriers, should be continued so that a basis can be laid for a fair and competitive climate for soliciting bids for interconnection services upon authorization from the Legislature.

Public Broadcasting in Pennsylvania

The Commonwealth of Pennsylvania is presently served by nine educational television stations in the state (Figure 1). Border areas will receive

additional service from numerous planned ETV stations in neighboring states (see Figure 2).

TABLE I

PUBLIC TELEVISION STATIONS IN PENNSYLVANIA

STATION	CHANNEL	CITY	LICENSEE
WHYY-TV	12	Wilmington, Del. (Philadelphia)	WHYY, Inc.
WUHY-TV	35	Philadelphia	WHYY, Inc.
WITF-TV	33	Hershey	South Central Educational Broadcasting Council
WLVT-TV	39	Allentown	Lehigh Valley Educational Television Corporation
WVIA-TV	44	Wilkes-Barre	Northeastern Pennsylvania Educational Television Association
WQLN-TV	54	Erie	Educational Television of Northwest Pennsylvania, Inc.
WPSX-TV	3	State College	Pennsylvania State University
WQED	13	Pittsburgh	Metropolitan Pittsburgh Educational Television
WQEX	16	Pittsburgh	Metropolitan Pittsburgh Educational Television

Most of the homes in Pennsylvania can receive at least one public station by direct "off air" reception. Certain areas, however, receive a marginal or inadequate television service on a direct reception basis because of intervening terrain. In these instances, Community Antenna Television systems (CATV) have come into being so that, in reality, very few homes in Pennsylvania are beyond the range of good broadcast television reception of one or more public television stations either by direct pickup or via CATV. More than 96 per cent of the homes are able to receive one or more public television stations.

Broadcast ETV coverage of Pennsylvania will be assisted by surrounding

states when their plans for stations are implemented. New York state anticipates several stations which will provide substantial service in the northern tier of Pennsylvania. Maryland has four stations planned in Baltimore, Frederick, Hagerstown, and Cumberland which will provide substantial coverage in the southern tier of Pennsylvania, and West Virginia has a station planned in Morgantown which will serve portions of southwest Pennsylvania. Each of these stations is part of a specific plan and is in some stage of funding or activation.

Thus, virtually 100 per cent of the population in Pennsylvania is or soon will be within reasonable reception means of one or more public television stations. Present FCC Rules reserve four noncommercial educational UHF channels in Pennsylvania for future activation in Altoona, Johnstown, Philadelphia, and State College. Channel allocation studies indicate that additional television channels probably could be assigned in the northcentral area of Pennsylvania through appropriate Rule-Making procedures with the FCC. These channels, if and when they are ever activated, will be supplemental to the public broadcast service presently available in each respective community area in a manner similar to the second station in Philadelphia and Pittsburgh.

The Proposed ETV Network System for Pennsylvania

The Pennsylvania ETV Network as proposed herein is a very flexible interconnection system in the form of a hub and spokes whereby each of the nine Pennsylvania ETV stations is provided with a two-way television interconnection to a central switching center. Thus, each station can receive and simultaneously provide programs to the rest of the state or regional network without scheduling conflicts with other stations. No program service or usage will be contingent upon clearing time with another station. Likewise, the preparation of programs between two or more stations can be accomplished readily with the provision of the two-way feeds. Normal interstate connections to networks such as the Eastern Educational Network (EEN), and National Educational Television (NET)

would be made at the central switching center.

Both EEN and NET have indicated complete cooperation with the proposed network in the choice of a permanent interstate network connection point. EEN, at present, provides a connection with WHYY at its Philadelphia studio, but the connection is of an "interim" nature until a proper tariff structure is drawn up by American Telephone and Telegraph Company (AT&T) and a more permanent financial structure is evolved by EEN for its cost. At such time, the Pennsylvania Network connection point would transfer to the central switching point.

In the other Reports to the Committee are the projected program schedules envisioned by each of these stations to show the need and use for the routing configuration proposed herein for Pennsylvania. A simplified route map, Figure 3, shows the pattern of operation as recommended by the station managers. The actual geographic route to be used by any system constructed is discussed in much greater detail in Appendix material. Additional parallel route connections are likely in the future, especially between the major station centers in Pittsburgh and Philadelphia.

The Pennsylvania ETV Network should have a capability that is consistent with the needs and the service available with modern equipment. Present day service capability is substantially beyond that provided up till now under conventional tariffs* by common carriers for educational or commercial service. However, these old tariffs were instituted some 15 or 20 years ago, before the needs of modern educational television were known.

Jansky & Bailey has recognized for many years the need for both capability and flexibility in the use of educational television systems. Through the past 10 years, we have stressed their importance in statewide system designs, regardless of whether they eventually were provided by common carrier lease, or were installed by an owned and operated facility

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*Such as American Telephone and Telegraph: Series 7001 (formerly Tariff 216); Series 7004 (formerly Tariff 253).

of the state. The systems that were installed as privately-owned (or state-owned) obtained this versatility by the choice of conservative system design and high quality equipment. The leased facilities, however, encountered many difficulties with policy questions from various common carriers. Thus, flexibility and performance of leased systems have evolved more slowly over the years. Such systems as now provided in Nebraska, Kentucky, and New York State illustrate some of the evolution of policies by the carriers in providing a more flexible pattern of usage for statewide educational television systems. Preliminary negotiations with five interested carriers indicate that most are in a policy posture that is able to provide the capability and flexibility desired for this system. Thus, the common carriers today appear to be very close to being able to provide all of the advantages previously possible only with a privately-owned system, and at prices generally competitive with privately-owned systems. If further negotiations and final bids by the common carriers live up to initial statements made thus far in this study, Pennsylvania can have a high performance, highly flexible ETV system, at a reasonable cost regardless of whether it is privately (or state) owned or leased from a common carrier.

A significant bonus will be the relative ease with which most of the stations may tie across state boundaries into other major ETV stations and networks. These auxiliary interstation and interstate routes will add greatly to the flexibility and reliability of the interstate networks. For instance, Wilkes-Barre may easily tie into the New York State Network at Binghamton. Erie may tie into the New York State Network at Buffalo, or may tie into the Ohio Network at Cleveland. Pittsburgh may tie to Morgantown or Cleveland. Hershey can tie readily to Baltimore and Washington. Allentown and Philadelphia can tie easily to New York City. Each of these suggested ties encompass relatively modest microwave expenditures, in most cases involving only two or three microwave relays. These auxiliary ties could be independently provided by facilities owned by the stations directly involved.

Any official extension of the intrastate Pennsylvania Network to include these auxiliary interstate ties across state boundary will involve

many decisions about operations, licensing, and costs. It appears, therefore, that such ties would be most expedient as a direct action by the stations involved, but subject to a future upgrading and integration into intrastate networks when policies, agreements, and needs are more clearly defined.

Master Switching Center

An essential part of any statewide ETV distribution network is a central point of operation. A network system does not function as an automatic machine. A variety of technical, clerical, and administrative functions are needed that are directed to effective operation of the network system. None of the existing stations has the space, manpower, or funds to devote to such network activity. None of the stations desires the activities of the center within its administrative or operational organization. Their responsibilities and efforts are clearly towards the broadcasting and program producing areas, not that of being a network center. The experience of at least one large ETV station (not in Pennsylvania) that did encompass a regional control center has shown that it is a parasite on the manpower, time, and performance of its public broadcast commitments and responsibilities. We recommend, therefore, that a Master Switching Center, separate and neutral from the individual stations, be a part of the network system.

The Master Switching Center must have good proximity to public transportation and freight services, via air, highway, and rail. The general communications industry in the area must be able to accommodate the distribution of some 20 or more new channels of video information. The relative pay scales and availability of qualified personnel also must be included.

Access to transportation is required by the switching center. If this service is not readily available or reliable, effective programming is seriously hampered.

The availability of microwave communication into the Master Switching Center is a critical consideration. The useable radio spectrum allotted to

microwave for carrying point-to-point television signals is already overloaded in many cities. Continued demands for new service have forced many carriers to use special video cables in cities at a cost many times more than regular microwave. Although performance is excellent, system cost considerations suggest the avoidance or at least the minimizing of expensive video cable pairs wherever possible.

The cost of the network system is, in part, related to the airline miles between terminals. The following table shows the total airline miles involved for various locations of the Master Switching Center:

TABLE II

Location of Main Switching Center	Total Airline Miles For the Proposed Network Plan A
Pittsburgh	2481
Philadelphia	2097
Harrisburg	1641
State College	1708

The most economical area in terms of airline distance is in the central portion of the Commonwealth with a slight preference for the Harrisburg area.

The final choice for specific location of the Switching Center may well depend in part on the bid responses received from common carriers. For instance, at least two carriers may be able to provide a lower system cost if the Center is located within their respective telephone franchise area. This arises because Harrisburg proper is in one telephone franchise, and suburban areas including Hershey are in another. Carriers can realize savings when the high channel density service close to the Switching Center is able to use portions of their own existing facilities instead of subleasing total service from another carrier.

Although the proposed microwave distribution system will not involve large numbers of personnel, several key positions will require extremely

competent people. It is, therefore, important to consider both the relative cost of such personnel and the availability in any given community.

Considering all of the above factors, it is our judgment as engineers that a location in the Harrisburg area is best. It offers a crossroads of transportation via interstate highway, rail, and airlines. Although the air transportation is perhaps marginal, it is sufficiently close to the major cities of Philadelphia, Baltimore, and Washington so that even under the most adverse flying conditions, two or three hours of land transportation brings the city to all-weather airports. Harrisburg is a communications center already developed for intrastate usage by common carriers, but it is not saturated with use so that microwave would be precluded. Further, the terrain around Harrisburg is very conducive to economical microwave communications. High mountain ranges or shadowed sections do not pose the problems they do in such cities as Pittsburgh and State College. It is by coincidence, and not a factor or engineering judgement, that Harrisburg is also the state capital, thereby gaining access and exposure to the facilities of the State Government.

The Master Switching Control Center will resemble in many aspects a modern office. However, certain special requirements must be incorporated in its design or location to provide the versatility commensurate with the rest of the system distribution. Approximately 10,000 square feet of floor space will be needed with up to half of this area containing specialized electronic equipment requiring a somewhat heavier air conditioning demand than is typical in most offices. The air conditioning must control both temperature and humidity on a year-round basis within very close tolerances. This conditioning is required to maintain stability of electronic equipments and for the storage of the video tape recordings.

The power required for the electronic equipment is quite typical of many office machines, but should have some extra degree of reliability. This is well within most power companies ability to provide especially in or near urban communities.

Perhaps the most difficult requirement for the location of the Master Switching Control Center will stem from a possible need for a microwave tower in close proximity to the building. This tower would resemble, in many respects, the ones frequently seen on telephone company buildings. The tower will have to support several bulky antennas at a height of some 100 to 300 feet above the ground. Because the antennas have to be very rigid in their positioning, the towers become quite massive in appearance and, therefore,tend to be obtrusive, especially in residential or parkland areas. It is possible, however, that if a tall building on an elevated site were available, the antennas could be located on the building roof.

Approximately half of the Master Switching Control Center would be devoted to offices for the traffic and managing personnel. No problem is envisioned in constructing or renovating this type of space, but it should be adjacent to the technical and storage areas. The office and technical areas would be expected to be in operation up to 18 hours or more per day, seven days a week. Therefore, certain access considerations must be given if the site is an existing building.

The costs for the Master Switching Center will be in direct proportion to the staff and equipment to be used. A small minimal Center would have low cost and very little ability to perform a meaningful traffic control function for the participants. Increasing the size (and cost) of the Center will tend to increase its value to the network stations. As with most decisions involving size versus value, a point of rapidly diminishing returns is reached as a system is enlarged.

A reasonable size for the proposed Control Center would be one that is commensurate with the network operation as already formulated in the route plan. Such a Center, based on comparable centers in other states, would typically include television tape recorders, film projection equipments, and network switching equipments plus suitable monitoring facilities. The cost would typically be:

TABLE III

	Purchase	Estimated Annual Lease
Building space 10,000 square feet	$ 300,000.	$ 60,000.
Technical Equipment	1,140,000.	262,200.*
Furniture and Fixtures	20,000.	5,000.
Miscellaneous	50,000.	15,000.
TOTAL	$1,510,000.	$342,200.

*Based on 1.92% per month

Annual operation would typically include such technical items as:

TABLE IV

Technical Staff	$105,000.
Technical Supplies	110,000.
Building maintenance	15,000.
Vehicle lease	3,000.
Miscellaneous	10,000.
TOTAL	$243,000.

The total annual cost for the Master Switching Center would typically be:

TABLE V

	Purchase	Lease
Depreciation:		
Equipment (5 years)	$228,000.	$262,200.
Building (15 years)	20,000.	60,000.
Other (8 years)	8,750.	20,000.
Operation	243,000.	243,000.
Average Interest (3%)	40,800.	-----
TOTAL	$540,550.	$585,200.

The outright purchase of equipment, though seeming slightly less in cost per year, was not endorsed by the managers of the Pennsylvania ETV stations. The preference was unanimous for leasing the equipment and space so that the over-all center capability will be nearly current with the rapidly changing technology of television and the needs of the network system users. Such a lease pattern has already been established in the Master Switching Center of Albany, New York as a part of the New York Network. A similar lease is reasonable for Pennsylvania.

Interconnection Available from Common Carriers

The proposed Pennsylvania ETV Network can be provided through leased services from common carriers such as the Bell Telephone Company of Pennsylvania, the General Telephone Company, Western Union, New York-Pennsylvania Microwave, or other similar companies providing this type of service. In providing an equitable and competitive basis for leased service, very carefully drawn specifications should be submitted to permit all carriers to quote on the same basis for service without needless disadvantage or restrictions.

Any common carrier proposing to provide service such as recommended herein may encounter the need for a large amount of new construction--the amount depending on the particular carrier. With the exception of the Pennsylvania Bell System (and its parent American Telephone and Telegraph Company), all bidding carriers probably would have to procure new sites and construct building facilities for much of the system. Pennsylvania Bell (through AT&T) appears to have most of the microwave sites needed already developed from existing telephone and television services. For this reason, it is possible that Pennsylvania Bell could supply the proposed system at lower cost and in a shorter time span than other carriers. This should not be assumed, however, until actual quotations for service have been received. Completion of the construction for start of

permanent interconnection service by leased facilities is believed possible by early 1969. Service before that date may be possible on an interim basis using existing or portable equipment, but probably would not meet the full requirements recommended herein.

Interconnection Availability as a Public Safety Radio Service

The Pennsylvania ETV Network might be provided as a state-owned and operated facility. Such a network could be considered within the FCC Rules covering Radio Communications and non-Federal Government Functions such as states or state agencies. Such a network would be governed by the FCC Rules and Regulations Part 89, Public Safety Radio Service. Section 89.1(b) states:

> This Part is designed to provide a service of radio communication essential either to the discharge of non-Federal Government functions or to the alleviation of an emergency endangering life or property.

Section 89.3(a) further defines the Public Safety Radio Service:

> Any service of radio communication essential either to the discharge of non-Federal Government functions or the alleviation of an emergency endangering life or property, the radio transmitting facilities of which are defined as fixed, land, mobile, or radio location stations.

Use of this Service is limited by Section 89.7:

> The radio facilities authorized under this Part shall not be used to carry program material of any kind for use in connection with radio broadcasting and shall not be used to render a communications common carrier service except for stations in the special emergency radio service while being used to bridge gaps in common carrier wire facilities. (emphasis added).

Thus, the use of the Public Safety Radio Service for interconnecting the ETV stations of the state by a state-owned and operated system would require a waiver of this limitation. Past experience has shown that such waivers, because of their very basic nature, are very difficult to achieve.

The frequencies available in the Public Safety Radio Service are not sufficient to accommodate a full system such as recommended in this report without utilizing frequencies with inherent short range capabilities. This requires shorter hops and a more carefully tested routing in order to achieve a reliable system. This could increase the cost of the system by a factor of 25 to 50%. In our judgement, the proposed network as a state licensed facility under the Public Safety Radio Service is not feasible.

Interconnection Availability as a Business Radio Service

The Pennsylvania State ETV Network could be provided under the Business and Industrial Rules of the FCC as detailed in Part 91. In general, the Rules are similar to the Public Safety Radio Service including the restriction on broadcast program material except that:

> Paragraph 91.2(b)
>
> The facilities of closed-circuit educational television systems that have been licensed to educational institutions in the Business Radio Service may be utilized for the transmission of program material to noncommercial educational television broadcast stations, provided that the use of the facilities exclusively for carrying such program material shall be less than 50 per cent of their total use during any one year of the license. No charge either direct or indirect shall be made for such use.

Eligibility for use of the Business Radio Service is open to:

(a) any person engaged in a commercial activity

(b) educational or philanthropic institutions

(c) clergymen or ecclesiastical institutions

(d) hospitals, clinics, and medical associations

(e) a subsidiary corporation proposing to furnish a non-profit radio communication service to its parent corporation or to another subsidiary of the same parent where the party to be served is engaged in one of the activities set forth above.

The frequencies available to the Business Radio Service are identical to and shared with the Public Safety Radio Service and the probability remains

that the system would have to use less desirable frequencies with their short range and higher costs.

The restriction on the percentage of use by broadcast ETV stations is not likely to be eased in the foreseeable future. Further, the exact corporate or agency makeup of the network could have serious limitations in the use of the Business Radio Service. In our judgement, the proposed network could not utilize this Service as the primary licensing vehicle for a state-owned system. The Business Radio Service would be useable as an auxiliary to a primary system provided by other means.

Interconnection Availability as a Broadcast Auxiliary Service

The Pennsylvania State ETV Network could be provided on frequencies that are available to broadcast television stations as detailed in Part 74 of the FCC Rules. A total of 42 frequencies are available under this service, but nearly half are shared with the Community Antenna Relay (CAR) Service which has, in many instances, largely saturated this service making it difficult for broadcast applicants to utilize. Any of the frequencies available in this service must be licensed to authorized television stations. This presents no theoretical limitation to their use in Pennsylvania, but a very practical problem arises in coordinating the various microwave licensees with the appropriate TV station.

The frequencies available in this part of the Rules are classed as Broadcast Auxiliary Services. Priority of use is accorded to studio-transmitter and remote pickup links, with secondary usage as intercity microwave. The TV stations in major urban areas such as Philadelphia and Pittsburgh are already utilizing most of the frequencies available. In rural areas whole blocks of the frequencies are being used by the Community Antenna Relay Services on a "shared" basis. Detailed study and allocation work would be necessary to be certain that a complete system could be achieved on the available frequencies using the Broadcast Auxiliary Service.

In all probability, an owned and operated system, whether state or station-owned and licensed, will require certain changes or waivers in the

FCC Rules for a completed system. An interim or supplemental system of limited capability probably could be achieved without waivers in the Broadcast Auxiliary Service. However, the corporate structure of the owning or holding organization would be a crucial element.

The availability of the optimum frequencies in the 6 to 7 GHz band appear to be difficult, if not impossible, in the more congested areas of the state. This means that portions of the system must be in the less desirable 10 to 13 GHz range necessitating shorter hops and more expensive installation. In general, equipment is readily available in the 6 to 7 GHz range, but is still limited in the higher frequencies to the remodulating type equipments rather than heterodyne equipment. There is every expectation that long haul heterodyne type equipment will be available from numerous manufacturers in the next year or two, but a competitive purchase for such equipments at this time would be difficult.

No direct investigation has been given thus far in this study to the problems of acquiring lease or purchase agreements for microwave sites. Past experience indicates that this could be a very lengthy and involved process. Exact ownership must be traced and a lease or purchase agreement negotiated for each of 25 to 30 sites. Such a process frequently takes as much as a year or more in some of the more rural areas. Even interagency transfers of state land can be very time consuming. Should a particular site be unavailable or unaccessible, a complete redesign of that section of the microwave system would be required, further adding to delay and cost.

Problems relating to the operation of a state owned network pose several significant areas of concern. First, an adequate service organization must be developed to maintain the system once it has been installed. A staff of 5 to 7 high caliber technicians with vehicles and test equipment would be required. The ability to find and hire the type of person frequently could be in conflict with established state pay scales and/or procedures. We have assumed that any owned and operated system would be purchased on a turnkey bases whereby the entire system would be installed and tested by the contractor for the equipment so that a large crew for

installation would not be required. The maintenance crew, however, should be on hand for field verification and supervision of the contractor crews as well as for general information and education about the system.

Costs for Common Carrier Services

The leasing of services from a common carrier is normally done under existing tariff rates and structures. At present there are at least two tariffs on file by the Pennsylvania Telephone Company for television interconnection, both of which are in common usage within the state. In a previous section, Interconnection Available from Common Carriers (page 11), the need is stated for carefully drawn specifications for such service. The question may be raised as to why the need for specifications if tariffs already exist.

The answer is first in the recognition that existing tariffs represent only one of numerous carriers that can and are believed willing to compete on a fair and equitable basis to provide the desired service. Using the tariff of one carrier as a basis of requesting bids for service may not be an equitable or fair basis for the other carriers.

Secondly, and perhaps most important, is that existing tariffs do not adequately provide for the specific needs of an educational or public broadcasting television network. Performance is limited and inadequate in light of today's technology. The existing tariffs tend to impose artificial restrictions in the use of the service, seriously limiting the flexibility and value of the interconnection service. Additionally, existing tariffs provide certain services such as fulltime monitoring and alternate route backup facilities that do not appear to be warranted in the educational broadcasting service.

For these reasons we are advocating Special Service Offerings by common carriers so that a better system, meeting the expressed needs of the users, can be provided at reasonable cost and with the maximum flexibility that is technically possible. With properly written system performance specifications, we believe leased interconnection service can be available to

Pennsylvania that will achieve a quality system at a competitive price in keeping with the service provided.

Using the special offering rates that have been negotiated in similar systems in other parts of the country, we have estimated the monthly cost of leasing service in Pennsylvania at approximately \$27 to \$28 per month per airline mile of one-way system. For some of the route plans considered, the cost would be

	Figure Number	Airline Miles	Estimated Annual Cost
Plan A	3	1641	\$551,000.
Plan B	6	1206	405,000.
Plan C	7	1524	512,000.
Plan D	8	1900	638,000.

The above cost estimates are believed to be representative of the magnitude, but should not be considered as final or binding upon any carrier.

In addition to the above lease costs, certain onetime special construction costs may be levied. These generally are less than 15% of the first year lease, but no real estimate can be made before a bona fide proposal by a carrier is received. Of course, any carrier will want reasonable assurance that he can recover his initial investment. Normally, this is achieved in the form of a declining termination charge over a period of 120 months.

If the total interconnection system is leased, the network will need only a skeleton technical staff for the Master Switching Center maintenance and for regular technical liaison and system test with the carrier. Typically this would involve the part time effort of the director of engineering and two of the technicians.

Costs for State Owned System

The cost of a state-owned and operated system will depend in large degree on the physical routing of the microwave network. In order to obtain reasonable estimates, we have considered two alternate designs

based on map studies. No field verification, path checks, or site availability has been made, but we believe the costs are indicative of those to be expected regardless of the exact routing that may finally be achieved. These costs include annual operation (maintenance, personnel, service parts, vehicles, test equipment, etc.), an eight year depreciation schedule, and an average interest rate of 3%. Taxes, real or not paid, have been omitted. The costs range between $678,000 to $680,000 per year. Detailed breakdowns of these cost estimates are given in Appendix A for further study and comparison.

Auxiliary Services

The ability of any complex network operation to function effectively depends in large measure upon its ability to provide a traffic service to its respective members. The proposed network system for Pennsylvania will require certain auxiliary communications services to be provided to each of the participating stations. These services include teletypewriter, dial telephone, private line telephone, and control lines. Leasing these services under existing tariff and rate structures appears to be the most economical and reliable method. The teletypewriter service for the present should be a continuation of the nationwide TWX* service now subscribed individually by most stations. Eventually, some consolidation may be desirable whereby only one TWX would be used at the central distribution point with a separate private teletypewriter service to each of the stations. This, however, does not appear justified at this time. The interstation telephone service could best be achieved through use of the existing state dial network system utilizing one or two phone lines to each of the participating stations. This would permit dialing without toll charges among the stations and to any connecting state phone. Private line telephone service

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*Teletypewriter Exchange Service of the Bell Telephone Company

would be provided through a State or Federal Telpak* structure from each station control room to the Central Switching Center for operations and technical order service. The control lines, if needed, would be provided in the same manner for interstation cues, order service, and remote control involving complex productions between two or more studios

All of these auxiliary services can be provided readily and economically through leased services in the existing state dial system and the State and Federal Telpak structures.

Typical annual costs would be:

TWX 8 units	$14,000.
Dial Net Service 16 units	7,000.
Private Line and Control Service	7,000.
	$28,000.

These cost estimates are very general based on rather broad assumptions. A more accurate estimate is currently being prepared by the Pennsylvania Bell Telephone representative.

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*Telpak is a special bulk rate pricing schedule of Bell Telephone Companies for intercity communication lines.

Summary

Pennsylvania presently receives Public Television service from at least nine stations, and border areas will, in time, receive added service from planned stations in neighboring states. In order to realize the full potential for the existing and any future Public Telephone stations, a flexible interconnection system for TV program distribution and exchange is essential. The instant engineering studies lead to the following recommendations to the Governor's Advisory Committee:

1. The interconnection system should be of the "hub and spoke" configuration for greatest flexibility. (See Plan A, figure 3).
2. The system should include a Master Switching Center using leased equipment located in the vicinity of Harrisburg. This Center should be separate and neutral from all stations for traffic and routing control, and program delay services. No program production services are envisioned at the Switching Center.
3. The interconnection system for television should be leased from a qualified common carrier on the basis of fair and competitive bids. Existing tariffs do not adequately provide for the specific needs of an educational or public television network.
4. Carefully drawn technical bid specifications for the TV network should be prepared by a person or organization with demonstrated expertise in such matters. Such preparation should be done in concert with the technical representatives of the stations and appropriate state agencies.
5. Auxiliary communications such as teletypewriters, dial exchange telephones, and private line service should be leased under the existing state dial network system and the Federal Telpak rate structure.

Expected annual costs for the proposed Pennsylvania Educational Television Network as recommended above:

TABLE VI

Annual Technical Costs

Plan A

TV interconnection	$551,000.
Auxiliary communications	28,000.
Master Switching Center	585,200.
TOTAL	$1,164,200

The above costs include all technical personnel, supplies, and lease charges.

During the formative years of the network operation, certain technical equipments and services can realistically be deferred to later years. Many of the stations of the network are not staffed or equipped to begin full time service. Although the flexibility of the "hub and spoke" operation is retained, which provides two-way service to each licensee, the one way interconnection service to the second stations at Pittsburgh and Philadelphia is deferred. Also, the first year equipments and operating costs may be reduced because the intra-state exchange is not expected to reach maximum hours. Thus certain cost items may be deferred (not eliminated) to the second or later year of operation when the quantity of program exchange requires the full complement of service and facilities.

The first year of operation could defer the following for later acquisition:

TABLE VII

Deferred Equipment and Services

	Annual lease cost
One-way interconnection for second stations Philadelphia and Pittsburgh	$87,000.
Equipment	104,717.
Auxiliary Communications	8,000.
Technical Operations	69,000.
TOTAL	$268,717

The expected annual costs for the first year of operation of the proposed Pennsylvania Educational TV Network as recommended above would be:

TABLE VIII

First Year Technical Costs

Technical	
TV Interconnection	$464,000.
Auxiliary Communications	20,000.
Master Switching Center	411,483.
Sub Total	$895,483
Administration and non-technical	82,200.
First year total	$977,683.

APPENDIX A

A STATE-OWNED MICROWAVE INTERCONNECTION

APPENDIX A

A STATE-OWNED MICROWAVE INTERCONNECTION

This Appendix describes the state-owned and operated concept of a television interconnection system to serve as the Pennsylvania ETV Network. Insofar as possible, the system is structured so that the cost analysis for the operation is comparable with the basis of the common carrier costs given elsewhere in the report. Therefore, direct comparison for various types of service and routings may be made regardless of how they are provided.

The basic routing configuration follows the general "hub and spoke" concept with variations to portray the range of costs that could be incurred. Numerous route configurations were appraised for cost and practicality, and the two judged most feasible and reasonable are presented in detail at the end of this Appendix. The costs are not based upon firm quotations by suppliers, but are estimated on the basis of current catalogue price information and recent construction costs.

The proposed microwave system on an owned and operated basis will be operational twenty-four hours a day, seven days a week except for such time as reasonably scheduled for maintenance and service. The system will have a capability of high quality television programs, several audio programs, and auxiliary communications services necessary for the operation of the microwave system. All of the Network proposed would be capable of transmitting high quality NTSC color television programs.

The minimum system designs provide two-way service from the Master Switching Center at Harrisburg to the stations on a share time basis (Plan B and C). The preferred system (Plan A) includes a two-way service to each station from the Switching Center without the need for sharing time. The expanded system (Plan D) provides an additional two-way link to Philadelphia and Pittsburgh. Once the initial system has been installed, additional service in either direction can be provided at substantially lower cost because much one-time investment has already been

made in land, buildings, towers, and antennas that would not have to be duplicated for additional service.

The system performance, using commercially available heterodyne long haul microwave equipment, will achieve that to be expected from any reliable common carrier. Such a system could transmit signals via connection to national networks for distribution throughout the U. S. without visible loss of picture quality. Thus, the capability within the state will be more than adequate to meet any foreseeable need for quality. Conservative design, proper maintenance, competent staffing, and proper choice of equipments and routes will provide a high degree of reliability and performance in the system. We do not anticipate the need, at least during initial years of operation, for the ultra reliability provided by standby RF equipment and alternate route capability. Such reliability may be desirable in the future and indeed is feasible by a variety of auxiliary interstate connections that do not require significant added expense or equipment.

The interconnection network design considerations are expected to meet the performance specifications outlined in another appendix. In general, the paths chosen and equipment proposed are for the 7.0 GHz band of frequencies with the expectation that the 11-13 GHz frequencies will be required in or near the urban cities such as Pittsburgh, Harrisburg, and Philadelphia. No attempt has been made in these studies to verify paths, sites, or frequency allocations except as they can be determined from map study. Complete field verification and site ownership searches would have to be made before any system design can be completed. Minor readjustments of some of the paths is entirely possible in later design stages.

An owned and operated system can provide a high degree of flexibility in use and a capability for changing its operation to accommodate a variety of special conditions. The problems of frequencies, licenses, and administration are covered in the body of the report because of their

importance and should not be overlooked in any serious consideration of an owned and operated system.

Network Costs

Estimated capital costs for the proposed system have been prepared for each of four basic operating route plans. These four plans (A through D) represent the range of operations considered feasible and useable by the managers. Plan A is preferred; Plan B is considered minimum; Plan C is a variation of the minimum plan; and Plan D is a probable future expansion of the preferred Plan A. Each Plan is priced out for two basic site designs.

PLAN A

PREFERRED SYSTEM

(see Figure 3)

Description of Item	Cost of System Design (see Figure 5A)	
	Design I	Design II
Capital Cost (Tables I-A & II-A)	$2,902,570.	$2,918,520.
Annual Cost		
Amortization (8 years)	$ 362,821.	$ 364,815.
Maintenance and Operation (Table III)	227,700.	227,700.
Interest (3%)	87,077.	87,556.
ANNUAL COST TOTAL	$ 677,598.	$ 680,071.

PLAN B

MINIMUM SYSTEM

(see Figure 6)

Description of Item	Cost of System Design (see Figure 5B)	
	Design I	Design II
Capital Cost (Tables IB & IIB)	$2,164,470.	$2,519,495.
Annual Cost		
Amortization (8 years)	$270,559.	$314,937.
Maintenance and Operation (Table III)	227,700.	227,700.
Interest (3%)	64,934.	75,585.
TOTAL ANNUAL COST	$565,193.	$618,222.

PLAN C

ALTERNATE MINIMUM SYSTEM

(see Figure 7)

Description of Item	Cost of System Design (see Figure 5C)	
	Design I	Design II
Capital Cost (Tables IC & IIC)	$1,740,420.	$2,117,170.
Annual Cost		
Amortization (8 years)	$217,553.	$264,646.
Maintenance and Operation (Table III)	227,700.	227,700.
Interest (3%)	52,213.	63,515.
ANNUAL CAPITAL COST	$497,466.	$555,861.

PLAN D

EXPANSION OF PLAN A

(see Figure 8)

Description of Item	Cost of System Design (see Figure 5D)	
	Design I	Design II
Capital Cost (Tables ID & IID)	$3,049,870.	$3,363,195.
Annual Cost		
Amortization (8 years)	$381,234.	$420,399.
Maintenance and Operation (Table III)	227,700.	227,700.
Interest (3%)	91,496.	100,896.
TOTAL ANNUAL COST	$700,430.	$748,995.

(see Figure 3, Plan A and Figure 5A, Design 1)

Description of Item	Unit Cost	Terminal Master Switching Center 7 Drops and Inserts 2 Drops only Location #17	Terminal Duplex Drops and Inserts 4 Locations: 1-13-18-24	Terminal 1 Drop and Insert 1 Insert only 2 Locations: 8-26	Terminal/Repeater 2-1/2 two way 1 Drop and Insert Location #21	Repeater 1 two-way 7 Locations: 2-3-4-5-6-22-23	Repeater 1-1/2 two-way Location #25	Repeater 2-1/2 two-way 4 Locations: 7-9-10-11	Repeater 3-1/2 two-way 6 Locations: 12-14-15-16-19-20
Transmitter	$ 7,500.	$ 52,500.	$ 30,000.	$ 30,000.	$ 7,500.				
Receiver	7,500.	67,500.	30,000.	15,000.	7,500.				
Repeater	15,000.				45,000.	$210,000.	$ 45,000.	$300,000.	$ 630,000.
Antenna (6' dish)	750.	2,250.	3,000.	1,500.	2,250.	10,500.	1,500.	6,000.	9,000.
Waveguide (150')	1,500.	4,500.	6,000.	3,000.	4,500.	21,000.	3,000.	12,000.	18,000.
Tower (100')	6,000.	6,000.				42,000.	6,000.	24,000.	36,000.
Insert Equipment	3,500.	24,500.	14,000.	14,000.	3,500.				
Drop Equipment	1,500.	13,500.	6,000.	3,000.	1,500.				
Fault Alarm:									
-Terminal Readout -Repeater Relay	5,000. 2,000.	45,000.	20,000.	20,000.	5,000. 6,000.	14,000.	4,000.	24,000.	42,000.
Communication Channel	1,500.	3,000.	6,000.	3,000.	1,500.	10,500.	1,500.	6,000.	9,000.
FM Audio	4,000.	36,000.	16,000.	16,000.	4,000.				
Spare Parts/site	600.	1,200.	2,400.	1,200.	600.	4,200.	600.	2,400.	3,600.
Building	3,500.					24,500.	3,500.	14,000.	21,000.
Land	2,000.					14,000.	2,000.	8,000.	12,000.
Auxiliary Power	4,500.					31,500.	4,500.	18,000.	27,000.
Site Improvement	2,500.					17,500.	2,500.	10,000.	15,000.
Engineering and Installation:									
-Terminal per Duplex -Repeater per Duplex	3,000. 5,000.	27,000.	12,000.	12,000.	3,000. 15,000.	35,000.	10,000.	60,000.	105,000.
CAPITAL COST		$282,950.	$145,400.	$118,700.	$106,850.	$434,700.	$ 84,100.	$538,400.	$ 927,600.
CONTINGENT (10% of TOTAL)		$ 28,295.	$ 14,540.	$ 11,870.	$ 10,685.	$ 43,470.	$ 8,410.	$ 53,840.	$ 92,760.
TOTAL COST		$311,245.	$159,940.	$130,570.	$117,535.	$478,170.	$ 92,510.	$592,240.	$1,020,360

TABLE I-B

MINIMUM SYSTEM

(see Figure 6, Plan B and Figure 5B, Design I)

Description of Item	Unit Cost	Terminal Master Switching Center 5 Duplex Drops and Inserts One location: #17	Terminal 1 Duplex Drop and Insert Six locations: 1-8-13-18-24-26	Terminal/Repeater 1 Drop and Insert 1-1/2 two-way One location: #21	Repeater 2 two-way 8 locations: 2-3-4-5-6 22-23-25	Repeater 2 two-way 10 locations: 7-9-10-11-12 14-15-16-19-20
Transmitter	$ 7,500.	$ 37,500.	$ 45,000.	$ 7,500.		
Receiver	7,500.	37,500.	45,000.	7,500.		
Repeater	15,000.			30,000.	$240,000.	$ 600,000.
Antenna (6' dish)	750.	2,250.	4,500.	2,250.	12,000.	15,000.
Wave Guide (150')	1,500.	4,500.	9,000.	4,500.	24,000.	30,000.
Tower (100')	6,000.	6,000.			48,000.	60,000.
Insert Equipment	3,500.	17,500.	21,000.	3,500.		
Drop Equipment	1,500.	7,500.	9,000.	1,500.		
Fault Alarm:						
-Terminal Readout	5,000.	25,000.	30,000.	5,000.		
-Repeater Relay	2,000.			10,000.	16,000.	40,000.
Communication Channel	1,500.	3,000.	9,000.	1,500.	12,000.	15,000.
FM Audio (2 channels)	4,000.	20,000.	24,000.	4,000.		
Spare Parts/site	600.	1,200.	3,600.	600.	4,800.	6,000.
Building	3,500.				28,000.	35,000.
Land	2,000.				16,000.	20,000.
Auxiliary Power	4,500.				36,000.	45,000.
Site Improvements	2,500.				20,000.	25,000.
Engineering and Installation:						
-Terminal per Duplex	3,000.	15,000.	18,000.	3,000.		
-Repeater per Duplex	5,000.			10,000.	40,000.	100,000.
CAPITAL COST		$176,950.	$218,100.	$84,850.	$496,800.	$ 991,000.
CONTINGENT (10% of TOTAL)		$ 17,695.	$ 21,810.	$ 8,485.	$ 46,680.	$ 99,100.
TOTAL COST		$194,695.	$239,910.	$93,335.	$546,480.	$ 1,090,100.

GRAND TOTAL $2,164,470

TABLE I-C

ALTERNATE MINIMUM SYSTEM

(see Figure 7, Plan C and Figure 5C, Design I)

Description of Item	Unit Cost	Terminal Master Switching Center 3 Duplex Drop and Inserts One location: #17	Terminals 1 Duplex Drop and Insert Six locations: 1-8-13-18-24-26	Terminal/Repeater 1 Drop and Insert 1 two-way One location: #21	Repeater two way 16 locations: 2-3-4-5-6-9 10-11-14-15-16 19-20-22-23-25	Repeater 1-1/2 two-way Two locations: 7 and 12
Transmitter	$ 7,500.	$ 22,500.	$ 45,000.	$ 7,500.		
Receiver	7,500.	22,500.	45,000.	7,500.		
Repeater	15,000.			30,000.	$480,000.	$ 90,000.
Antenna (6' dish)	750.	2,250.	4,500.	2,250.	24,000.	4,500.
Wave Guide (150')	1,500.	4,500.	9,000.	4,500.	48,000.	9,000.
Tower (100')	6,000.	6,000.			96,000.	12,000.
Insert Equipment	3,500.	10,500.	21,000.	3,500.		
Drop Equipment	1,500.	4,500.	9,000.	1,500.		
Fault Alarm:						
-Terminal Readout	5,000.	15,000.	30,000.	5,000.		
-Repeater Relay	2,000.			4,000.	32,000.	8,000.
Communication Channel	1,500.	3,000.	9,000.	1,500.	24,000.	3,000.
FM Audio (2 channels)	4,000.	12,000.	24,000.	4,000.		
Spare Parts/site	600.	1,200.	3,600.	600.	9,600.	1,200.
Building	3,500.				56,000.	7,000.
Land	2,000.				32,000.	4,000.
Auxiliary Power	4,500.				72,000.	9,000.
Site Improvements	2,500.				40,000.	5,000.
Engineering and Installation:						
-Terminal per Duplex	3,000.	9,000.	18,000.	3,000.		
-Repeater per Duplex	5,000.			10,000.	80,000.	20,000.
CAPITAL COST		$112,950.	$218,100.	$84,850.	$993,600.	$172,700.
CONTINGENT (10% of TOTAL)		$ 11,295.	$ 21,810.	$ 8,485.	$ 99,360.	$ 17,270.
TOTAL COST		$124,245.	$239,910.	$93,335.	$1,092,960.	$189,970.

GRAND TOTAL $1,740,420

(see Figure 8, Plan D and Figure 5D, Design I)

Description of Item	Unit Cost	Terminal Master Switching Center 9 Duplex Drop and Inserts 1 Location: #17	Terminals Two-way Drop and Inserts 4 Locations: 1-13-18-24	Terminals 2 two-way Drop and Inserts 2 Locations: 8-26	Terminal/Repeater 3 two-way 1 Drop and Insert One Location: #21	Repeater 2 two-way 7Locations: 2-3-4-5 6-22-23	Repeater 2 two-way 1 Location: #25	Repeater 3 two-way 6 Locations: 7-9-10-11-19-20	Repeater 4 two-way 4 Locations: 12-14-15-16
Transmitter	$ 7,500.	$ 67,500.	$ 30,000.	$ 30,000.	$ 7,500.				
Receiver	7,500.	67,500.	30,000.	30,000.	7,500.				
Repeater	15,000.				90,000.	$210,000.	$ 60,000.	$540,000.	$480,000.
Antenna (6' dish)	750.	2,250.	3,000.	1,500.	2,250.	10,500.	1,500.	9,000.	6,000.
Waveguide (150')	1,500.	4,500.	6,000.	3,000.	4,500.	21,000.	3,000.	18,000.	12,000.
Tower (100')	6,000.	6,000.				42,000.	6,000.	36,000.	24,000.
Insert Equipment	3,500.	31,500.	14,000.	7,000.	3,500.				
Drop Equipment	1,500.	13,500.	6,000.	3,000.	1,500.				
Fault Alarm:									
-Terminal Readout	5,000.	45,000.	20,000.	20,000.	5,000.				
-Repeater Relay	2,000.				6,000.	14,000.	4,000.	36,000.	32,000.
Communication Channel	1,500.	3,000.	6,000.	3,000.	1,500.	10,500.	1,500.	9,000.	6,000.
FM Audio (2 channels)	4,000.	36,000.	16,000.	16,000.	4,000.				
Spare Parts/site	600.	1,200.	2,400.	1,200.	600.	4,200.	600.	3,600.	2,400.
Building	3,500.					24,500.	3,500.	21,000.	14,000.
Land	2,000.					14,000.	2,000.	12,000.	8,000.
Auxiliary Power	4,500.					31,500.	4,500.	27,000.	18,000.
Site Improvements	2,500.					17,500.	2,500.	15,000.	10,000.
Engineering and Installation:									
-Terminal per Duplex	3,000.	27,000.	12,000.	12,000.	3,000.				
-Repeater per Duplex	5,000.				15,000.	35,000.	10,000.	90,000.	80,000.
CAPITAL COST		$304,950.	$145,400.	$126,700.	$151,850.	$434,700.	$ 99,100.	$816,600.	$692,400.
CONTINGENT (10% of TOTAL)		$ 30,495.	$ 14,540.	$ 12,670.	$15,185.	$ 43,470.	$ 9,910.	$ 81,660.	$ 69,240.
TOTAL COST		$335,445.	$159,940.	$140,370.	$167,035.	$478,170.	$109,010.	$898,260.	$761,640.

GRAND TOTAL $3,049,870

TABLE II-A

PREFERRED SYSTEM

(see **Figure** 3, Plan A and Figure 5A, Design II)

Description of Item	Unit Cost	Terminal Master Switching Center 7 Drops and Inserts 2 Drops Only Location #19	Terminal Duplex Drops and Inserts 3 Locations: 1-24-31	Terminal 1 Drop and Insert 1 Insert only Location #15	Terminal/Repeater 1 two-way 1 Drop and Insert Location #9	Terminal/Repeater 1-two-way 1 Drop and Insert 1 Insert Only Location #29	Terminal/Repeater 2-1/2 two-way 1 Drop and Insert Location #25	Repeater 1 two-way 12 Locations: 2-3-4-5-6-7-8 20-21-22-23-30	Repeater 1-1/2 two-way 4 Locations: 11-12-13-14	Repeater 2-1/2 two-way 7 Locations: 10-16-17-18-26-27-28
Transmitter	$ 7,500.	$ 52,500.	$ 22,500.	$ 15,000.	$ 7,500.	$ 15,000.	$ 7,500.			
Receiver	7,500.	67,500.	22,500.	7,500.	7,500.	7,500.	7,500.			
Repeater	15,000.				30,000.	30,000.	45,000.	$360,000.	$180,000.	$525,000.
Antenna (6' dish)	750.	2,250.	2,250.	750.	1,500.	1,500.	2,250.	18,000.	4,500.	10,500.
Waveguide (150')	1,500.	4,500.	4,500.	1,500.	3,000.	3,000.	4,500.	36,000.	9,000.	21,000.
Tower (100')	6,000.	6,000.						72,000.	24,000.	42,000.
Insert Equipment	3,500.	24,500.	10,500.	7,000.	3,500.	7,000.	3,500.			
Drop Equipment	1,500.	13,500.	4,500.	1,500.	1,500.	1,500.	1,500.			
Fault Alarm:										
-Terminal Readout	5,000.	45,000.	15,000.	10,000.	5,000.	10,000.	5,000.			
-Repeater Relay	2,000.				2,000.	2,000.	6,000.	24,000.	16,000.	42,000.
Communication Channel	1,500.	3,000.	4,500.	1,500.	1,500.	1,500.	1,500.	18,000.	6,000.	10,500.
FM Audio	4,000.	36,000.	12,000.	8,000.	4,000.	4,000.	4,000.			
Spare Parts/site	600.	1,200.	1,800.	600.	600.	600.	600.	7,200.	2,400.	4,200.
Building	3,500.							42,000.	14,000.	24,500.
Land	2,000.							24,000.	8,000.	14,000.
Auxiliary Power	4,500.							54,000.	18,000.	31,500.
Site Improvements	2,500.							30,000.	10,000.	17,500.
Engineering and Installation:										
-Terminal per Duplex	3,000.	27,000.	9,000.	6,000.	3,000.	6,000.	3,000.			
-Repeater per Duplex	5,000.				5,000.	5,000.	15,000.	60,000.	40,000.	105,000.
CAPITAL COST		$282,950.	$109,050.	$ 59,350.	$75,600.	$ 94,600.	$106,850.	$745,200.	$331,900.	$847,700.
CONTINGENCY (10% of TOTAL)		$ 28,295.	$ 10,905.	$ 5,935.	$ 7,560.	$ 9,460.	$ 10,685.	$ 74,520.	$ 33,190.	$ 84,770.
TOTAL COST		$311,245.	$119,955.	$ 65,285.	$83,160.	$104,060.	$117,535.	$819,720.	$365,090.	$932,470.

TABLE II-B

MINIMUM SYSTEM

(see Figure 6, Plan B and Figure 5B, Design II)

Description of Item	Unit Cost	Terminal Master Switching Center 6 Duplex Drop and Insert Location #19	Terminal Duplex Drop and Insert 4 Locations: 1-15-24-31	Terminal/Repeater 1 Drop and Insert 1 two-way Location #9	Terminal/Repeater 1 Drop and Insert 1-1/2 two-way Location #29	**Terminal**/Repeater 1 Drop and Insert 2 two-way Location #25	Repeater 1 two-way 16 Locations: 2-3-4-5-6-7-8 11-12-13-14-20 21-22-23-30	Repeater 2 two-way 7 Locations: 10-16-17-18-26-27-28
Transmitter	$ 7,500.	$ 45,000.	$ 30,000.	$15,000.	$ 7,500.	$ 7,500.		
Receiver	7,500.	45,000.	30,000.	15,000.	7,500.	7,500.		
Repeater	15,000.				30,000.	60,000.	$480,000.	$420,000.
Antenna (6' dish)	750.	2,250.	3,000.	1,500.	1,500.	1,500.	24,000.	10,500.
Waveguide (150')	1,500.	4,500.	6,000.	3,000.	3,000.	3,000.	48,000.	21,000.
Tower (100')	6,000.	6,000.					96,000.	42,000.
Insert Equipment	3,500.	21,000.	14,000.	3,500.	3,500.	3,500.		
Drop Equipment	1,500.	9,000.	6,000.	1,500.	1,500.	1,500.		
Fault Alarm:								
-Terminal Readout	5,000.	30,000.	20,000.	5,000.	5,000.	5,000.		
-Repeater Relay	2,000.			2,000.	2,000.	4,000.	32,000.	28,000.
Communication Channel	1,500.	3,000.	6,000.	1,500.	1,500.	1,500.	24,000.	10,500.
FM Audio (2 channels)	4,000.	24,000.	16,000.	4,000.	4,000.	4,000.		
Spare Parts/site	600.	1,200.	2,400.	600.	600.	600.	9,600.	4,200.
Building	3,500.						56,000.	24,500.
Land	2,000.						32,000.	14,000.
Auxiliary Power	4,500.						72,000.	31,500.
Site Improvements	2,500.						40,000.	17,500.
Engineering and Installation:								
-Terminal per Duplex	3,000.	18,000.	12,000.	3,000.	3,000.	3,000.		
-Repeater per Duplex	5,000.			5,000.	5,000.	10,000.	80,000.	70,000.
CAPITAL COST		$208,950.	$145,400.	$60,600.	$75,600.	$112,600.	$993,600.	$693,700.
CONTINGENT (10% of TOTAL)		$ 20,895.	$ 14,540.	$ 6,060.	$ 7,560.	$ 11,260.	$ 99,360.	$ 69,370.
TOTAL COST		$229,845.	$159,940.	$66,660.	$83,160.	$123,860.	$1,092,960.	$763,070.

GRAND TOTAL $2,519,495

TABLE II-C

ALTERNATE MINIMUM SYSTEM

(see Figure 7, Plan C and Figure 5C, Design II)

Description of Item	Unit Cost	Terminal Master Switching Center 3 Duplex Drop and Insert 1 Location: #19	Terminals 1 Duplex Drop and Insert Four Locations; 1-15-24-31	Terminal/Repeater 1 Drop and Insert 1 two-way 3 Locations: 9-25-29	Repeater Two-way 23 Locations: 2-3-4-5-6-7-8-11 12-13-14-16-17-18-20 21-22-23-26-27-28-30	Repeater 1-1/2 two-way One location: #10
Transmitter	$ 7,500.	$ 22,500.	$ 30,000.	$ 22,500.		
Receiver	7,500.	22,500.	30,000.	22,500.		
Repeater	15,000.			45,000.	$660,000.	$ 45,000.
Antenna (6' dish)	750.	2,250.	3,000.	4,500.	33,000.	2,250.
Waveguide (150')	1,500.	4,500.	6,000.	9,000.	66,000.	4,500.
Tower (100')	6,000.	6,000.			132,000.	6,000.
Insert Equipment	3,500.	10,500.	14,000.	10,000.		
Drop Equipment	1,500.	4,500.	6,000.	4,500.		
Fault Alarm:						
-Terminal Readout	5,000.	15,000.	20,000.	15,000.		
-Repeater Relay	2,000.			6,000.	44,000.	4,000.
Communication Channel	1,500.	3,000.	6,000.	4,500.	66,000.	1,500.
FM Audio (2 channels)	4,000.	12,000.	16,000.	12,000.		
Spare Parts/site	600.	1,200.	2,400.	1,800.	13,200.	600.
Building	3,500.				77,000.	3,500.
Land	2,000.				44,000.	2,000.
Auxiliary Power	4,500.				98,000.	4,500.
Site Improvements	2,500.				55,000.	2,500.
Engineering and Installation:						
-Terminal per Duplex	3,000.	9,000.	12,000.	9,000.		
-Repeater per Duplex	5,000.			15,000.	110,000.	10,000.
CAPITAL COST		$112,950.	$145,400.	$181,800.	$1,398,200.	$86,350.
CONTINGENT (10% of TOTAL)		$ 11,295.	$ 14,540.	$ 18,180.	$ 139,820.	$ 8,365.
TOTAL COST		$124,245.	$159,940.	$199,980.	$1,398,200.	$94,985.

GRAND TOTAL $2,117,170

TABLE II-D

EXPANSION OF PLAN A

(see Figure 8, Plan A and Figure 5D, Design II)

Description of Item	Unit Cost	Terminal Master Switching Center 9 Duplex with Drops and Inserts Location #19	Terminals Duplex Drops and Inserts 3 Locations: 1-24-31	Terminals 2 Duplex Drops and Inserts Location #15	Terminal/Repeater 1 two-way 1 Drop and Insert Location #9	Terminal/Repeater 1 two-way 2 Drops and Inserts Location #29	Terminal/Repeater 3 two-way 1 Drop and Insert Location #25	Repeater two-way 12 Locations: 2-3-4-5-6-7-8 20-21-22-23-30	Repeater 2 two-way 4 Locations: 11-12-13-14	Repeater 3 two-way 3 Locations: 26-27-28	Repeater 4 two-way 4 Locations: 10-16-17-18
Transmitter	$ 7,500.	$ 67,500.	$ 22,500.	$15,000.	$ 7,500.	$ 15,000.	$ 7,500.				
Receiver	7,500.	67,500.	22,500.	15,000.	7,500.	15,000.	7,500.				
Repeater	15,000.				30,000.	30,000.	90,000.	$360,000.	$250,000.	$270,000.	$480,000.
Antenna (6' dish)	750.	2,250.	2,250.	750.	1,500.	1,500.	1,500.	18,000.	6,000.	4,500.	6,000.
Waveguide (150')	1,500.	4,500.	4,500.	1,500.	3,000	3,000.	3,000.	36,000.	12,000.	9,000.	12,000.
Tower (100')	6,000.	6,000.						72,000.	24,000.	18,000.	24,000.
Insert Equipment	3,500.	31,500.	10,500.	7,000.	3,500.	7,000.	3,500.				
Drop Equipment	1,500.	13,500.	4,500.	3,000.	1,500.	3,000.	1,500.				
Fault Alarm:											
-Terminal Readout -Repeater Relay	5,000. 2,000.	45,000.	15,000.	10,000.	5,000. 2,000.	10,000. 2,000.	5,000. 6,000.	24,000.	16,000.	18,000.	32,000.
Communication channel	1,500.	3,000.	4,500.	1,500.	1,500.	1,500.	1,500.	18,000.	6,000.	4,500.	6,000.
FM Audio (2 channels)	4,000.	36,000.	12,000.	8,000.	4,000.	8,000	4,000.				
Spare Parts/site	600.	1,200.	1,800.	600.	600.	600.	600.	7,200.	2,400.	1,800.	2,400.
Building	3,500.							42,000.	14,000.	10,500.	14,000.
Land	2,000.							24,000.	8,000.	6,000.	8,000.
Auxiliary Power	4,500.							54,000.	18,000.	13,500.	18,000.
Site Improvements	2,500.							30,000.	10,000.	7,500.	10,000.
Engineering and Installation:											
-Terminal per Duplex -Repeater per Duplex	3,000. 5,000.	27,000.	9,000.	6,000.	3,000. 5,000.	6,000. 5,000.	3,000. 15,000.	60,000.	40,000.	45,000.	80,000
CAPITAL COST		$304,950.	$109,050.	$68,350.	$75,600.	$107,600.	$149,600.	$745,200.	$396,400.	$408,300.	$692,400.
CONTINGENT (10% of TOTAL)		$ 30,495.	$ 10,905.	$ 6,835.	$ 7,560.	$ 10,760.	$ 14,960.	$ 74,520.	$ 39,640.	$ 40,830.	$ 69,240.
TOTAL COST		$335,445.	$119,955	$75,185.	$83,160.	$118,360.	$165,560.	$819,720.	$436,040.	$449,130.	$761,640.

GRAND TOTAL $3,363,195

TABLE III

OPERATION AND MAINTENANCE COSTS FOR A MICROWAVE INTERCONNECTION SYSTEM FOR PENNSYLVANIA

Description	Annual Cost
Building and property maintenance of all sites	$ 20,000.
Tower maintenance and alignment of all sites	20,000.
Vehicle, Truck (6) - 2 year lease	15,000.
Vehicle operation and maintenance	25,000.
Test Equipment (6 sets) - 5 year lease	15,000.
Replacement parts (6 sets)	12,000.
Technicians (5)	65,000.
Supervisor (1)	15,000.
Travel expenses, overtime, insurance, etc.	20,000.
Contingent expenses	20,700.
ANNUAL TOTAL	$227,700.

APPENDIX B

COMMON CARRIERS

APPENDIX B

COMMON CARRIERS

The communications common carrier is any person or company engaged in rendering a communications service for hire to the public. In the communications field, it is a highly regulated business. Both federal and state statutues control many aspects of operation, area of service, quality of service, and rate structures. The intent, of course, is to prevent undue proliferation of communications services to the detriment of the actual service to the public.

Of the several bona fide communications common carriers providing communications services in Pennsylvania, a number of them have been contacted as a part of the current studies for the Governor's Advisory Committee to ascertain their interest and capability in supplying the television communications service for the Pennsylvania ETV Network. All of the carriers contacted thus far have expressed an interest in bidding, on a fair and equitable basis, for the service as proposed in this report. We are endeavoring herein to present to the Committee a representative cross section of carriers believed to have the capability of providing the television service desired and to whom bid proposals should be submitted when duly authorized by the State Legislature.

The larger common carriers in Pennsylvania include the Bell Telephone Company of Pennsylvania, an affiliate of the Bell Telephone System, and the York Telephone Company at Erie, Pennsylvania. There are, however, at least thirteen additional independent companies (listed in Table I on page B-3 following) which appear by their gross revenue to be of sufficient size to be capable of providing this service.

In addition to telephone companies, there are several common carriers specializing in television communications for community antenna systems in and around Pennsylvania. These are listed in Table II on page B-4 following and should also be included in any bidders list.

There are several independent common carriers outside Pennsylvania that may have authority and interest in submitting a competitive bid for the television service in Pennsylvania. These are included in Table III on page B-4 following.

The key point to be illustrated by this appendix is that common carriers, though they are oftentimes a non-competitive industry, are able to be very competitive among the various operating companies when an equitable basis can be provided. It should never be assumed that service is available from only a single carrier. Each will have particular attributes and capabilities, yet each carrier may have inherent weaknesses and shortcomings in providing such a service. Carefully written bid specifications will do much to alleviate the problems of obtaining high quality service from common carriers.

TABLE I

MAJOR INDEPENDENT TELEPHONE COMPANIES IN PENNSYLVANIA

COMMONWEALTH TELEPHONE COMPANY
Dallas, Pennsylvania

CONESTOGA TELEPHONE & TELEGRAPH COMPANY
Birdsboro, Pennsylvania

DENVER & EPHRATA TELEPHONE AND TELEGRAPH COMPANY
Ephrata, Pennsylvania

GENERAL TELEPHONE COMPANY OF PENNSYLVANIA
Erie, Pennsylvania

HOME TELEPHONE COMPANY OF RIDGWAY
Ridgway, Pennsylvania

KITTANNING TELEPHONE COMPANY
Kittanning, Pennsylvania

MEADVILLE TELEPHONE COMPANY
Meadville, Pennsylvania

MURRAYSVILLE TELEPHONE COMPANY
Export, Pennsylvania

NORTH PITTSBURGH TELEPHONE COMPANY
Gibsonia, Pennsylvania

PEOPLES-UNITED TELEPHONE CORPORATION
Butler, Pennsylvania

SOUTH PENN TELEPHONE COMPANY
Waynesburg, Pennsylvania

UNITED TELEPHONE COMPANY OF PENNSYLVANIA
Carlisle, Pennsylvania

YORK TELEPHONE AND TELEGRAPH COMPANY
Erie, Pennsylvania

TABLE II

CATV COMMON CARRIERS

SERVICE ELECTRIC COMPANY

NEW YORK-PENNSYLVANIA MICROWAVE, INC.
Syracuse, New York

PENNSYLVANIA MICROWAVE, INC.
Hazelton, Pennsylvania

PENNSYLVANIA SERVICE MICROWAVE COMPANY

* * * * *

TABLE III

OTHER COMMON CARRIERS

CONTINENTAL TRANSMISSION CORPORATION
Clayton, Missouri

UNITED TELEPHONE COMPANY
Kansas City, Missouri

MID-CONTINENT TELEPHONE COMPANY
Elyria, Ohio

BELL TELEPHONE COMPANY OF PENNSYLVANIA
Harrisburg, Pennsylvania

WESTERN UNION
Government Communications
Alexandria, Virginia

SAMPLE LETTER OF INQUIRY SENT TO COMMON CARRIERS.

JANSKY & BAILEY
RADIO AND ELECTRONIC ENGINEERS
WASHINGTON, D. C.

ADCAST & TELEVISION ENGINEERING
COMMUNICATION ENGINEERING

MOVED TO:
SUITE 200
1812 K ST., N. W.
WASH., D. C. 20006

2411 M STREET, N.W.
WASHINGTON, D. C. 20037
AREA CODE: 202
TELEPHONE: 296-6400

October 26, 1967

Mr. A. J. Eicholzer
NEW YORK-PENNSYLVANIA MICROWAVE
1030 James Street
Syracuse, New York 13203

On behalf of the Governor's Advisory Committee on Public Television, we are preparing engineering studies, surveys, and recommendations on a statewide ETV distribution system for the Commonwealth of Pennsylvania.

The operational plan for the Pennsylvania ETV Network proposes to use a central master switching center in the vicinity of Harrisburg for routing both intrastate and interstate TV programming among the nine existing ETV stations in Pennsylvania and the national and regional ETV networks (such as the Eastern Educational Network and National Educational Television).

The basic system will consist of nine two-way (duplex) microwave circuits from a central point near Harrisburg, Pennsylvania radially to 7 terminals at the existing ETV stations in the Commonwealth of Pennsylvania. Each microwave circuit will be a fulltime dedicated system for the transfer of wideband video information typically consisting of NTSC color television and modulated subcarriers having a combined baseband of approximately 7.5 MHz.

The seven terminal locations are the studios of:

WLTV	Allentown, Pennsylvania
WPSX	State College
WQLN	Erie
WITF	Hershey
WHYY/WUHY	Philadelphia
WQED/WQEX	Pittsburgh
WVIA	Wilkes-Barre

Based on one two-way circuit to each station (thus two two-way circuits to Pittsburgh and Philadelphia), a total of 947 air-line miles of duplex

A DIVISION OF ATLANTIC RESEARCH CORPORATION

microwave are envisioned. (See attached map.) Of course, the actual distance spanned by the total microwave hops of an installed system will be somewhat larger.

The system performance with NTSC color television would be expected to equal or exceed the performance of EIA Standard RS250A. Minor tightening of certain specifications should be expected where reasonable using current commercially available equipments. Video performance must be achieved while simultaneously transmitting up to 3 FM modulated subcarriers in the 6.0 to 7.5 MHz range of the baseband. These subcarriers would carry program audio for TV and FM (typically 50 Hz to 15 KHz input modulation) with the third subcarrier for encoded stereo (50 Hz to 60 KHz input modulation).

The system should use long haul heterodyne microwave equipments such as Raytheon KTR-III and Lenkurt 75A systems. Good engineering practice in all aspects of design, installation, and operation will be mandatory. Battery standby power, conservative radio design, regular maintenance by competent personnel, access to service records, and timely response to system failures are proposed in lieu of standby RF equipments and circuits.

We would like to establish informal discussions with your representatives that, through a better understanding of the system desired, will lead to a fair and competitive basis for bids for this video service. Your questions, comments, and suggestions will be most helpful to us as we begin assembling the form and word of the proposed bid specifications. The informal discussions are expected to lead eventually to the issuance of formal bid requests for service by the Commonwealth upon authorization by the Legislature. To this purpose, I would suggest a meeting at your convenience the week of November 13. Meanwhile, please do not hesitate to call if you have questions.

Roger E. Peterson
Consulting Engineer

REP:mc

enclosure
cc: Mr. Albert J. Nesbitt

RESPONSES RECEIVED FROM COMMON CARRIERS RE LETTER OF INQUIRY.

G T & E COMMUNICATIONS INC.
730 THIRD AVENUE, NEW YORK, N. Y. 10017
TELEPHONE | AREA CODE 212 551-1000

NTON F. STEWART
RESIDENT & GENERAL MANAGER

October 31, 1967

Mr. Roger E. Peterson
Consulting Engineer
Jansky & Bailey
Suite 200
1812 K Street, N. W.
Washington, D. C. 20006

Dear Mr. Peterson:

We appreciate your promptness in forwarding the letter of October 26 to us. We are currently reviewing the letter, and its attachment, with the various other General Telephone & Electronics companies which would be involved in such a project.

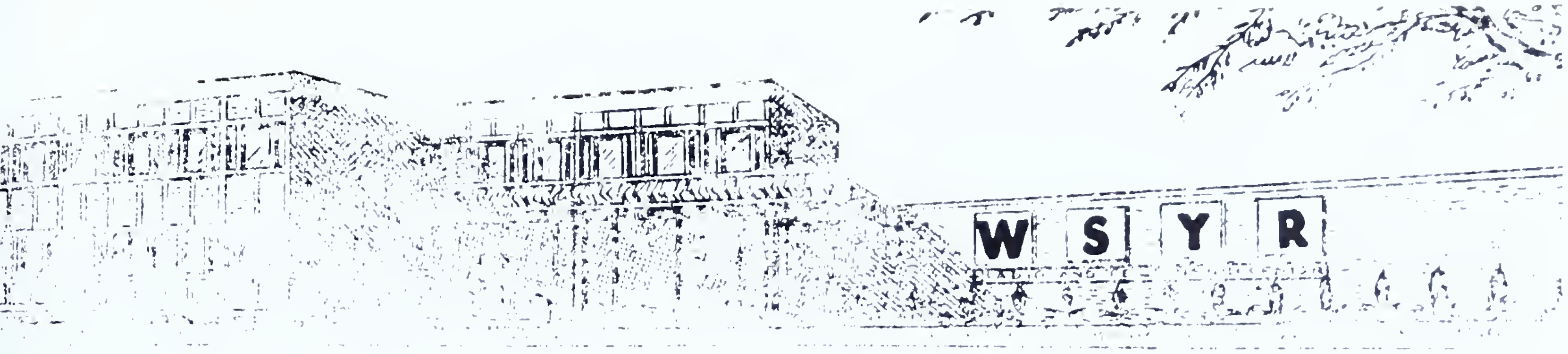
We will be contacting you again in the near future regarding a meeting during the week of November 13, 1967.

Very truly yours,

W. F. Stewart

Wenton F. Stewart

WFS:br



BASIC NBC AFFILIATE • 1030 JAMES STREET, SYRACUSE, N. Y. 13203 • GRANITE 4-3911

November 3, 1967

Mr. Roger E. Peterson
Consulting Engineer
Jansky & Bailey
Suite 200
1812 K Street, N. W.
Washington, D. C. 20006

Dear Mr. Peterson:

Thank you very much for your letter of October 26th, outlining the requirements of the Pennsylvania ETV Network. Your previous telephone conversation with me indicated that this was a crash program with an early deadline. This, in itself, puts us at a tremendous disadvantage.

I have no objection whatsoever to a meeting here in Syracuse on November 16th or 17th to discuss the matter. However, the previous history of this same project in the State of Pennsylvania leads me to believe that any effort we might put into this project would be lost. In order to generate any real enthusiasm, I would have to have some very strong assurance that we would be considered on an equal basis with the Telephone Company.

You will recall that several months of research and work went into the bid for New York State and the same procedure would be necessary for Pennsylvania. Additionally, I cannot see how our figure would change in relationship to the Telephone Company bid. I never did find out whether or not the Telephone Company supplied the system as we were asked to bid on it. Please let me know as to the meeting date, and we'll be glad to talk.

Sincerely,

A. J. Eicholzer
General Manager
New York Penn Microwave Corp.

AJE:ph

cc: Mr. E. R. Vadeboncoeur
Mr. John Murray

NEWHOUSE BROADCASTING CORPORATION

THE BELL TELEPHONE COMPANY OF PENNSYLVANIA

210 PINE STREET, HARRISBURG, PA.

AREA CODE 717
232-4101

FRANK J. ERTZ
CCOUNT MANAGER—COMMONWEALTH

November 28, 1967

Mr. R. E. Peterson, Consulting Engineer
Jansky and Bailey
Broadcast-Television Department of Atlantic Research
1812 K Street, N. W.
Washington, D. C.

Dear Mr. Peterson:

This is in regard to your letter dated October 26, 1967, and the information which you requested in our informal discussions. We offer the following relative to the provision of a Statewide ETV network service for the Commonwealth of Pennsylvania.

We are interested in providing an ETV service that would meet the needs of the Commonwealth of Pennsylvania as outlined in your letter and specifications. We would appreciate being included among those invited to bid on this service.

We have carefully reviewed your letter and the preliminary specifications outlining the type of system to be provided. We can provide a service with NTSC color television performance equalling the requirements set forth in EIA standard RS250A dated February, 1967. We would agree to minor tightening of these specifications if this could be accomplished by the use of currently available equipment.

We can provide up to 4 FM audio channel services transmitted simultaneously with the video signal. These channel services could be used for television audio and FM program audio providing nominal bandwidths of 50 hz to 15 khz. The provision of encoded stereo in lieu of several of these channels could also be considered. It must be recognized that multiple audio services will reduce the signal to noise ratio of both the video and audio channels.

In providing network service to meet the specifications, we would use long haul heterodyne microwave equipments as well as other transmission media of equivalent performance.

As indicated in your letter, performance and maintenance information will be made available to any duly authorized representative.

The interval to provide a service of this magnitude is 18 months from the date of receipt of a firm order. However, if an earlier date is required by the Commonwealth of Pennsylvania, every reasonable effort will be expended to improve this interval.

The Final specifications to be issued in connection with the invitation to bid will, of course, provide the basis for determining the charges. As you know, these charges and the regulations for a service interconnecting the ETV Broadcast Stations in Pennsylvania would be subject to review by the Federal Communications Commission.

In view of the expanding use of ETV, it is gratifying to know that the Commonwealth of Pennsylvania is exploring the feasibility of establishing a statewide ETV network. The Bell Telephone Company of Pennsylvania is vitally interested in serving the communications needs of the Commonwealth. We feel that as a result of our knowledge and vast experience we are completely qualified to provide this ETV network for the Commonwealth, stressing quality, reliability, speed of maintenance and economy.

We hope that our comments on your preliminary specifications have been helpful. If you have any questions, please call me.

Sincerely,

Henry J

Sales Manager
for Account Manager-Commonwealth

western union

December 14, 1967

Mr. Roger E. Peterson
Jansky & Bailey
Suite 200
1812 K Street N.W.
Washington, D.C. 20006

Subj: Pennsylvania ETV Network

Dear Roger:

Your letter of October 27, 1967 to Mr. Donald C. Johnson has been given to me for acknowledgment and reply.

The contents of your October 27 letter as well as the attached map showing terminal locations has been reviewed by our New York Headquarters, and we find that we can provide the technical facilities and know-how to accomplish this network. However, after much consideration and with the knowledge of the competitive tariff, it was decided that the cost for Western Union to provide the services required was not consistent with the competitive tariff offering. Accordingly, although our interest is high to perform such work, it would be inappropriate to commit our resources when it is so obvious our cost proposal would not be competitive.

Again, we appreciate being alerted to this opportunity and hope that some time in the future we will be able to competitively serve this market.

R L Barrett
R. L. Barrett

RLB:bs

cc: D. C. Johnson

GOVERNMENT COMMUNICATIONS SYSTEMS
2009 14TH STREET, NORTH, ARLINGTON, VIRGINIA 22201
(703) 524-9270 TELEX 89-484

APPENDIX C

MASTER SWITCHING CENTER

APPENDIX C
MASTER SWITCHING CENTER

The effective operation of a complex television distribution system will depend in large measure on the capabilities of the Master Switching Center. A well equipped, properly designed, and adequately staffed Center will obviously be capable of much more versatility and utility than one that is minimal. Based upon the experience of other Master Switching Centers now operating, such as those at Albany, New York, Boston, Massachusetts, and Lincoln, Nebraska, our judgement of a properly equipped center is both practical and in keeping with the recommended microwave distribution. The Center could be started on a more modest scale, but the expectation would be that the full facilities of the recommended Center would be needed within one year's time from start of operations. Later years should anticipate an even greater expansion in the facilities of the Center. Some effort to allow for such expansion would be justified inasmuch as later addition of space tends to be costly.

The Operation of the Center

In its simplest function, the Center provides the services of a traffic route switcher whereby each station would be supplied connecting circuits to other stations or networks according to a prearranged schedule. In practice, this simplicity has not been achieved. Time schedules, last minute changes, news events, technical and human elements, all come into play so that none of the existing operations of Master Switching Centers can be called simple.

Fairly elaborate monitoring means must be provided so that quality control may be maintained with precise timing. Tape recording and playback are needed for program delay, backup, or clock time origination for distribution. Film projectors and film cameras are required for similar reasons. Because any technical system must be maintained, some provision

must be provided for a small shop and its test equipment.

The day-to-day and moment-by-moment operation of the network requires auxiliary information to flow among the stations and the Control Center for schedules, routing orders, cues, monitoring, and similar non-program material, but all contributing to and needed for quality programming and a professional operation.

Most of the centers now in operation are staffed between 60 and 100 hours per week, with the Boston Center in operation up to 110 hours. In general, the hours will be governed by the start and end of the broadcast day for the network stations. Interconnection by network has a strong tendency to increase the broadcast hours of a station. Therefore, the likelihood of 90 to 100 hours per week even at the beginning is very high.

Equipment and Space Requirements

A network center requires a program switching system at its heart. This may be a video and audio switcher such as at Boston, Massachusetts or Lincoln, Nebraska, or it may be a more sophisticated one such as the combined IF-Video switcher at Albany in the New York Network. Either type can be provided, and the choice is largely an engineering one based on such factors as over-all technical quality, costs, operating pattern, physical location of the switching center, etc. The significant difference in the two types of switching is that the IF type permits through signals to pass the center without demodulation, thereby achieving somewhat better technical quality.

Any switching system requires adequate picture and waveform monitoring. Generally, this means a monitor set on every input and output of the switcher. In practice some variation may be encountered, but until more specifics are known, we have assumed a full group of monitor sets (combined picture and waveform monitors). The total interconnection system will be fully color capable. This will require some of the monitor sets to include an additional color monitor.

The element of time flexibility is important in a network of this type. Not all stations and networks can achieve a compromise time for receiving programs. A certain amount must be recorded at the convenience of one station and played back at the convenience of another. Ideally, each output of the center might be supplied from a tape recorder. In practice, this is not likely to occur. For the Center proposed herein, 5 television tape recorders of the Ampex VR1200 type are recommended. This will provide a diversity of recorders that can be expected to provide a combined recording-playback time of 15,000 to 18,000 hours annually. By close scheduling, up to 25,000 hours annually could be achieved. Most centers fill unscheduled hours with copy service (dubbing), routine maintenance, and machine service.

Some programming can be expected to be distributed at the Center from color film. At least one color film unit should be included. The New York Network has two such units (4-16 mm projectors, 2 color film cameras, 2 slide projectors); Boston has one unit; Lincoln has two units. We recommend herein that two units be incorporated at the Center, with space provided to accommodate a third unit in the future.

The Switching Center has a potential value as a technical co-ordinating center for affiliated stations and networks. A unique feature is the frequency coordination of the color standards at each station so that live productions from several stations may be interleaved within a single program. Details of a commercial unit are included at the end of this appendix. In addition, a wide variety of reference standards can be embodied in the network structure to enable all stations to have a continual source of test and calibration signals for improved technical performance.

The space requirements of the Center can range up to 10,000 square feet of office, technical, and tape storage areas. Probably 6,000 square feet would be adequate at the start, but the provision for growth of the Center should allow the addition of the remaining 4,000 feet in

the next two to five years without costly moving or rebuilding. The space is typical of modern office construction. It must have constant, year round temperature and humidity control for stability of film and tape equipments. The air must be reasonably clean and dust free for proper operation of film and switching equipment. The space must have 24 hour, 7 day access for fulltime operation and/or maintenance. Floor loads range from typical 60 lbs per square foot in office areas, to 100 lbs in the technical areas, and up to 200 lbs in the tape storage areas. Some offices might encounter problems with the required cables and lines from telephone companies or other carriers. A duct or wire way equivalent to 12 four inch conduits could be needed. Some carriers may choose to install antennas on the building roof. Where this might be the case, the added weight may pose problems on the building structure. The Bell Telephone Company has indicated it would not require antennas on a Center building in downtown Harrisburg, but would need sufficient duct or wire way for a number of cables (perhaps 25-30), each up to one inch in diameter. In some existing buildings, this could be a substantial construction burden.

The entire area would preferably have a vinyl tile concrete floor, semi-movable walls, and an easily accessible hung ceiling (such as the 2' x 4' panels laid in horizontal rails). This would permit most wiring to be concealed above in trays for easy service and installation.

Personnel Requirements

The technical personnel required at the Center should be estimated on the basis of three shifts of two technicians each plus two maintenance men and a director of engineering (total 9). All must have a good level of competence with television equipment, especially color tape recorders and microwave.

When first starting a new operation, it is unfortunate that most all personnel must be purchased in a sellers market that is already

unusually high priced. There is little or no opportunity to obtain untrained but willing-to-learn persons for more reasonable sums. The New York Network found they had to pay some 15% to 20% above locally prevailing broadcast rates to attract competent personnel. Operators receive $9-10,000, maintenance men $12,000, and the director of engineering $17,000. Major cities such as Boston, New York, Philadelphia, and Washington, D. C. might have to pay $5,000 to $6,000 more in each category.

Other Considerations

The Center must include a limited amount of space for the terminal equipment of the microwave carrier. This space must be near the cable or duct entrance to the floor area and typically is 250 to 300 square feet in a closed room. Space should also be allotted for a technical shop. An area of about 200 square feet is normal. Part of the office area would be devoted to traffic personnel including teletypewriters, files, telephones, etc., for program schedule coordination.

TABLE I

Technical Equipment

MASTER SWITCHING CENTER

5	Ampex VR 1200 B High Band, Color Tape Recorder	$ 526,000.
2	Color film units including 4 16mm film projectors 2 Color film cameras 2 Slide projectors 2 Optical multiplexers 2 Control and monitor console	215,000.
1	Master Switching System video and audio, fast lap 24 x 24, expandable to 24 x 48	130,000.
1	Monitoring and test accessories	56,000.
1	Audio Tape recorders and Miscellaneous accessories	12,000.
2	Sync generators, distribution and Phase lock accessories	41,000.
1	Miscellaneous spare parts and tools	10,000.
200	Tape stock	26,000.
20	Tape storage cabinets	8,000.
2	Portable microwave units	56,000.
	Installation and test	60,000.
	TOTAL	$1,140,000.

Annual Lease cost (estimated) for 5 years $ 262,200.*

---

*based on 1.92% per month.

TABLE II

First Year

Technical Equipment

MASTER SWITCHING CENTER

3	Ampex VR 1200 B High Band, Color Tape Recorder	$ 315,600.
1	Color film units including 2 16mm film projectors 1 Color film camera 1 Slide projector 1 Optical multiplexer 1 Control and monitor console	107,500.
1	Master Switching System video and audio, fast lap 24 x 24, expandable to 24 x 48	130,000.
1	Monitoring and test accessories	28,000.
1	Audio Tape recorders and Miscellaneous accessories	6,000.
2	Sync generators, distribution and Phase lock accessories	20,500.
1	Miscellaneous spare parts and tools	10,000.
20	Tape storage cabinets	8,000.
	Installation and test	60,000.
	TOTAL	$685,600.

Annual Least cost (estimated) for 5 years	$157,483*

*based on 1.92% per month.

AN INTRODUCTION TO TRACOR-SULZER PRECISION TELEVISION EQUIPMENT

TRACOR-Sulzer now offers state-of-the-art precision in TV synchronization. Fades, split-screen presentations, and other special effects between any number of independent video sources is now possible with color or monochrome signals -- even if the sources are geographically separated by 6000 miles or more.

Precise synchronization is made possible by controlling the timing equipment of each video facility with TRACOR-Sulzer precision 3.58 MHz subcarrier standards. A choice of two such standards are available: TRACOR-Sulzer Model RS–2.5 quartz crystal standard or TRACOR Model 304-SC rubidium atomic standard. Frequency accuracies of ± 5 parts per 10^{11} are attainable with either model. In more familiar form, the subcarrier frequencies are accurate to ±0.002 Hz. Figure 1 illustrates the significance of precision subcarrier standards in terms of accumulated timing errors and subcarrier phase errors as a function of frequency accuracy.

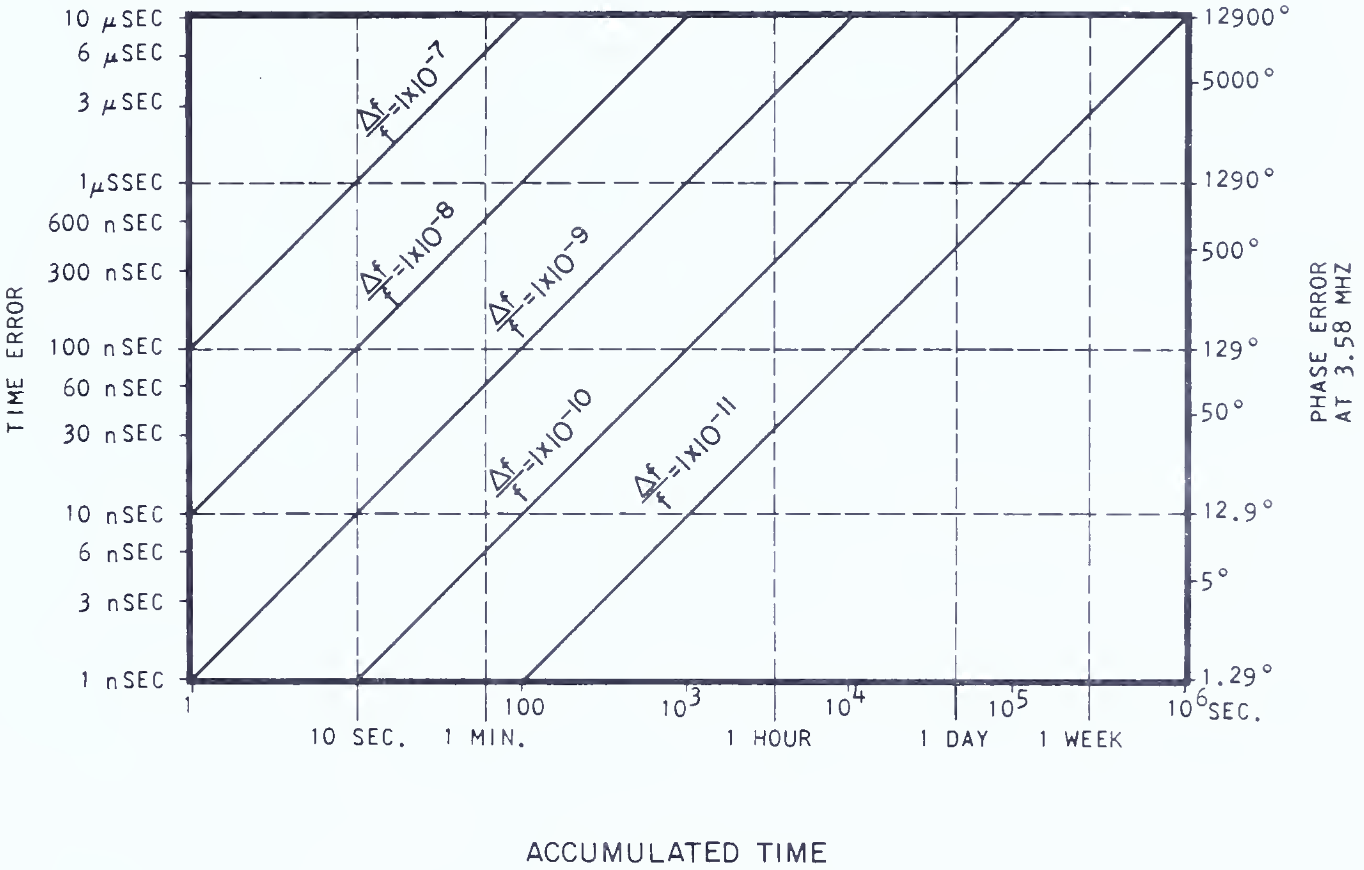
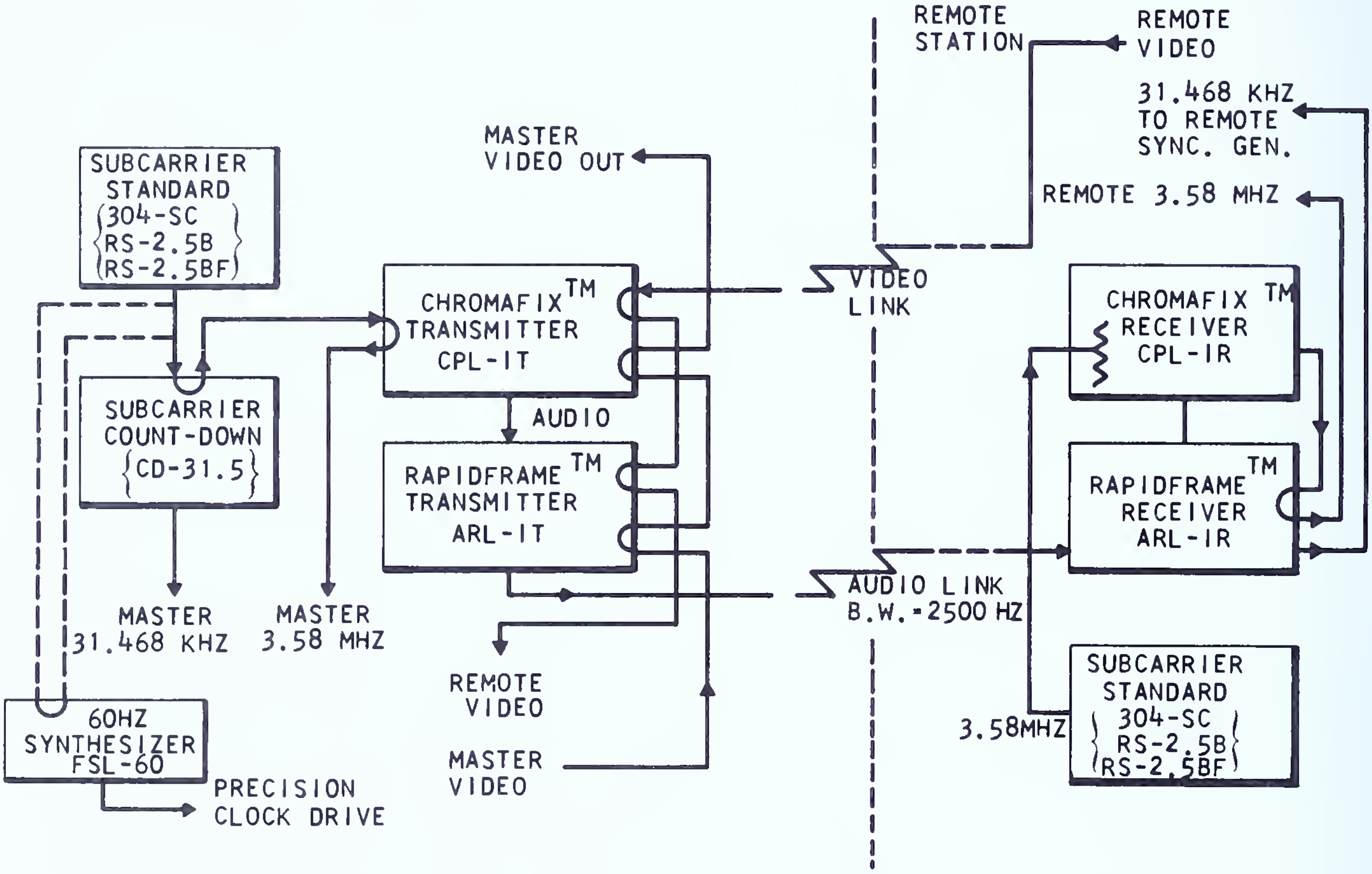


Figure 1

In addition to the subcarrier frequency standards, TRACOR-Sulzer has developed the Model ARL–1 RAPIDFRAME system which automatically synchronizes video rasters to within 0.1 microseconds and the Model CPL–1.0 CHROMAFIX system which automatically synchronizes color subcarriers to within ± 1.5° of phase. Each of these systems maintains synchronization by correcting either the timing or phase errors as they accumulate with time. It is technically possible to correct accumulating errors in systems operating from less precise subcarrier standards than the TRACOR-Sulzer units: However, the bandwidth of the synchronization data link between video sources is inversely proportional to the subcarrier accuracy.

The accuracy of the Model RS-2.5 or Model 304-SC makes it possible to operate the RAPIDFRAME or CHROMAFIX systems with a low quality telephone data link (2500 Hz line). Not only can such a low cost data link be utilized, but both the RAPIDFRAME and CHROMAFIX systems may operate simultaneously with the *same* telephone line. Also, due to the small bandwidth, the telephone service may be interrupted for several minutes without seriously disturbing synchronization.


SUBCARRIER STANDARD {304-SC RS-2.5B RS-2.5BF}
SUBCARRIER COUNT-DOWN {CD-31.5}
MASTER 31.468 KHZ
MASTER 3.58 MHZ
60HZ SYNTHESIZER FSL-60
PRECISION CLOCK DRIVE
MASTER VIDEO OUT
CHROMAFIX™ TRANSMITTER CPL-IT
AUDIO
RAPIDFRAME™ TRANSMITTER ARL-IT
REMOTE VIDEO
MASTER VIDEO
VIDEO LINK
AUDIO LINK B.W.≈2500 HZ
REMOTE STATION
REMOTE VIDEO
31.468 KHZ TO REMOTE SYNC. GEN.
REMOTE 3.58 MHZ
CHROMAFIX™ RECEIVER CPL-IR
RAPIDFRAME™ RECEIVER ARL-IR
3.58MHZ
SUBCARRIER STANDARD {304-SC RS-2.5B RS-2.5BF}

AUTOMATIC PRECISION TV SYNCHRONIZING EQUIPMENT

In addition to the above equipment, TRACOR-Sulzer provides other television timing and synchronization equipment such as:

Models TV – A, B, and C – Audio controlled synchronizing units for remotely controlling video facilities separated by a few miles (50 miles or less).

Model CD – 31.5 – Countdown unit which synthesizes 31.5 KHz from 3.58 MHz.

Model FSL – 60 – Synthesizer which generates a precise 60 Hz from 3.58 MHz for driving studio clock sources.*

Other auxiliary equipment is available from TRACOR-Sulzer for monitoring both time and frequency.

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*If a clock is controlled by a frequency source accurate to ± 1 part per 10^9, the clock will gain or lose one second in 32 years.

APPENDIX D

AN OUTLINE OF MINIMUM PERFORMANCE STANDARDS FOR THE PENNSYLVANIA ETV NETWORK

APPENDIX D

AN OUTLINE OF MINIMUM PERFORMANCE STANDARDS FOR THE PENNSYLVANIA ETV NETWORK

1. The basic network shall be an IF heterodyne microwave system of the 1800 message unit type of equipments.

2. The total intrastate system shall carry NTSC and PAL color television signals and such other educationally related information as may be technically feasible within the base bandwidth of the system.

3. Video Performance

A.	System Gain:	0 db ± 0.25 db
B.	Gain Stability:	
	Short term (1 sec)	± 0.25 db
	Long term (1 hour)	± 0.5 db
C.	Video Signal-to-Weighted Noise Ratio (P-P/RMS)[a]:	better than 60 db under median propagation conditions
D.	Video Frequency Response (Baseband)[b]:	
	1 KHz to 4.5 MHz	± 0.5 db
	1 KHz to 8.5 MHz	± 1.0 db
E.	Single Frequency Noise[c]:	
	S/I (P-P/P-P) 1 KHz to 2 MHz	better than 60 db
	Linear decrease from 2 to 4.5 MHz	better than 48 db
	Linear decrease from 4.5 to 7 MHz	better than 40 db
F.	Hum	
	S/Hum (P-P/RMS): unclamped	better than 50 db
G.	60 Hz Square Wave Tilt:	
	Unclamped	± 5%
	Clamped	± 1%

H. Differential Gain (3.58 MHz)[d]:	
50% APL	± 0.5 db
10% and 90% APL	± 0.8 db
I. Differential Phase (3.58 MHz)[d]:	
50% APL	± 1.0°
10% and 90% APL	± 1.5°
J. Sin^2 Pulse and Half-Line Bar[e]:	
K Factor 2t Pulse	less than 2%
t Pulse	less than 12%

4. Audio Performance (with simultaneous EIA test pattern video)

A. Channel A (to be provided on an FM subcarrier between 6.2 and 8.3 MHz)

1) Frequency Response:	within ± 0.5 db, 30 hz to 12 KHz
2) Harmonic Distortion:	less than 1% at 100% modulation between 30 Hz and 15 KHz
3) Signal-to-Noise Ratio: (RMS/RMS)	better than 58 db at 100% modulation

B. Channel B (a stated extra cost option or provided by customer equipment)

1) Performance same as Channel A
2) Input and output position to be provided at no added cost if customer provides modulated subcarrier equipment

C. Channel C (a stated extra cost option or provided by customer equipment)

1) Frequency Response:	within ± 1.0 db 30 Hz to 80KHz
2) Harmonic distortion	less than 1% at 100% modulation between 30 Hz and 40 KHz

3) Signal-to-Noise Ratio: (RMS/RMS)	better than 55 db 30 Hz to 55 KHz
4) Input and output position to be provided at no added cost if customer provides modulated subcarrier equipment.	

5. System Reliability

A. Video Signal-to-Noise Ratio:	better than 52 db P-P/RMS at least 80% of each month
	better than 48 db P-P/RMS at least 99% of each month
	better than 28 db P-P/RMS at least 99.95% of each month

Notes:

a. Measurements of continuous random noise will be made in accordance with CCIR Recommendation 421 (Volume V, 1963) including use of appropriate low pass and high pass filters and an instrument having a time constant of 0.4 second. The weighting characteristic shall be that given in Recommendation 421 for the U.S.A.

b. The frequency response from 60Hz to k KHz is usually assisted by clamp circuits. The frequency response shall be measured by a constant amplitude sine wave or by a swept frequency method in which the composite synchronization wave form and the test signal are displayed on an oscilloscope.

c. The ratio of pteak-to-peak value of interfering tone (single frequency noise) to the peak-to-peak value of the desired signal shall be measured using an oscilloscope or spectrum analyzer. If a spectrum analyzer is used, RMS values will be obtained. These measurements shall be made in order to insure that the intermodulation products are at acceptable levels when several information

channels are being transmitted in addition to the television signal.

d. Differential Gain and Phase at 3.58 mhz shall be measured according to 60 IRE 23.S1.

e. K factor to be determined in accordance with Recommendation 421.

APPENDIX E

COMPARISON TO OTHER DATA

APPENDIX E

COMPARISON TO OTHER DATA

The information derived in the course of our studies for the Committee may be grouped for interpretation in a variety of ways. Some of this data is presented on the following pages and chart. By using the comparisons, many judgements about costs, performance, and relative importance can be made with greater certainty and ease.

TABLE I

COMPARISON OF NEW YORK NETWORK AND PROPOSED PENNSYLVANIA ETV NETWORK

		New York Network	Equivalent Penn.*	Preferred Plan A*	Equivalent NY Network*
1.	Air line miles (one way)	816	970	1641	1576
2.	Monthly cost	$ 22,590.	$ 27,160.	$ 45,948.	$ 44,128.
3.	Annual cost	271,080.	321,264.	551,376.	529,536.
4.	Monthly cost per airline mile	27.60	28.	28.	27.60
5.	Number of stations served	5		9	
6.	Network staff	19-22		15	
7.	Equipment lease per year	$207,000.		$ 262,200.	
8.	Personnel cost per year	254,000.		187,200.	
9.	Microwave least per year	271,080.		551,376.	
10.	Miscellaneous and maintenance per year	87,000.		138,000.	
	SUB TOTAL	$819,080.		$1,138,776.	
11.	Building space lease			60,000.	
12.	Furniture and fixtures			5,000.	
13.	Building maintenance			15,000.	
14.	Vehicle lease			3,000.	
15.	Contingent			25,000.	
	TOTAL ANNUAL COST			$1,246,776.	

---

*Estimated lease

TABLE II

MICROWAVE COST COMPARISONS

	in Indiana (1967)	Existing NY Net. (1966)	Proposed Pennsylvania ETV Network State-owned and Operated PLAN A Design I	Proposed Pennsylvania ETV Network State-owned and Operated PLAN A Design II
ANNUAL COST[1]	$563,400.	$271, 080.	$677,598.	$680,071.
1. Route miles[2]	1192	925	2074	1940
2. Airline miles[3]	980	816	1641	1641
3. System miles	645	466	509	587
4. Channel density	1.84	2.0	4.0	3.5
5. Average hop length (miles)	17.4	29.1	20.4[4]	19.6[4]
6. Number of microwave sites	39	17	26	31
7. Cost per TV station served/mo.	$3200.	$3200.	$5646.	$5667.
8. Cost per microwave site/mo.	1150.	1325.	2172.	2180.
9. Cost per equipment location/mo.	937.	1070.	1569.	1574.
10. Cost per Channel mile				
Route miles/mo.	$ 37.80	$ 24.40	$ 27.22	$ 29.21
Airline miles/mo.	45.90	27.60	34.00	34.53

Comments:

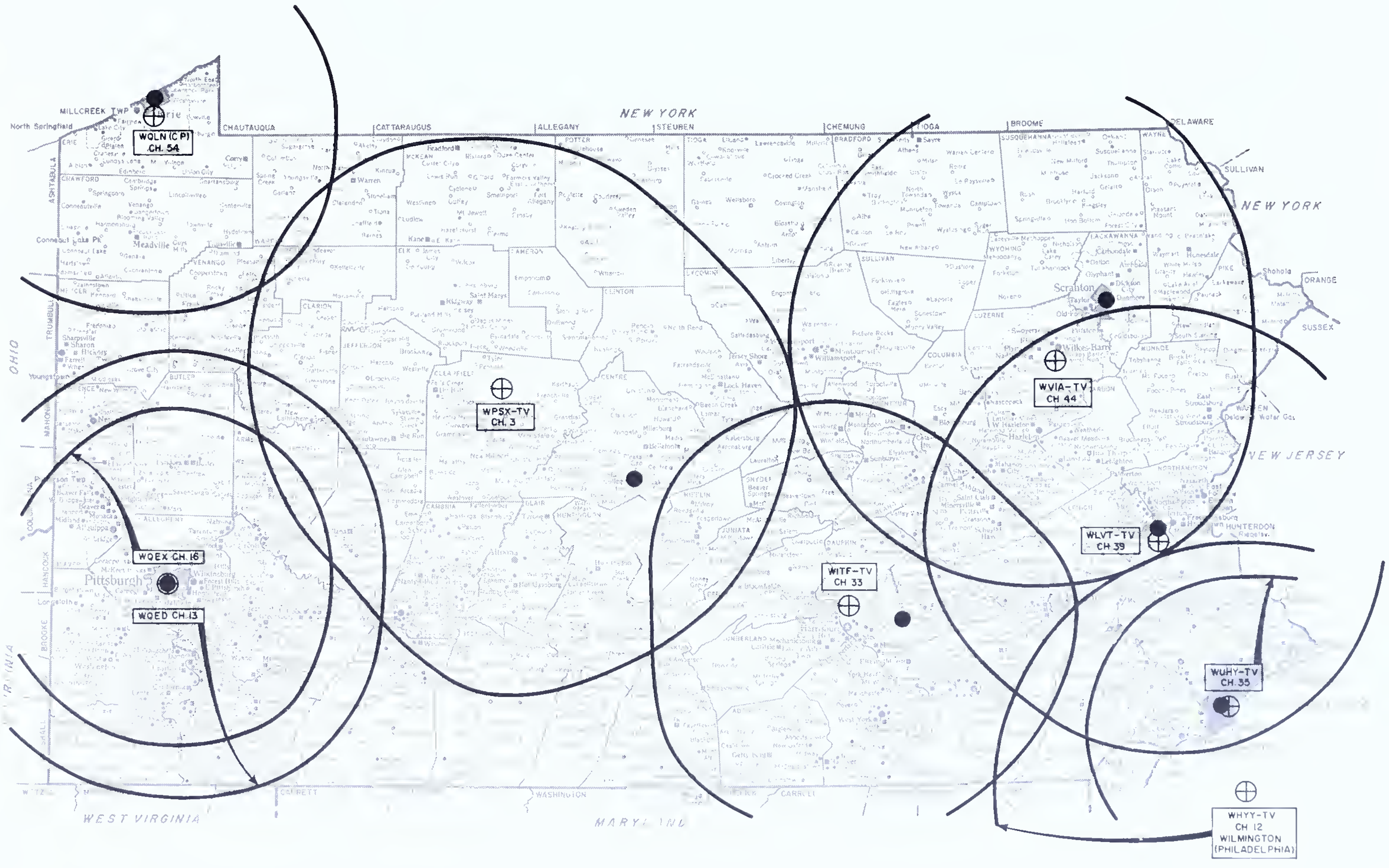
[1] Plan A includes all construction and operating costs. The NY Network and the proposed Indiana Network include only additional costs over and above facilities now existing.

[2] Route miles is the cumulative distance of all one way microwave hops.

[3] Airline miles is the cumulative one-way airline distances between terminal points.

[4] Average microwave hop length is a "worst case" example. Some improvement is believed possible in a final design.

11-13-67



KEY

● – STUDIO

⊕ – TRANSMITTER SITE

NOTE GRADE B CONTOURS CALCULATED USING MAXIMUM EFFECTIVE RADIATED POWER AND CURRENT DATA ON FILE WITH THE FEDERAL COMMUNICATIONS COMMISSION.

FIG 1

CALCULATED GRADE B CONTOURS OF PUBLIC TELEVISION STATIONS IN PENNSYLVANIA

COMMONWEALTH OF PENNSYLVANIA

11-13-67

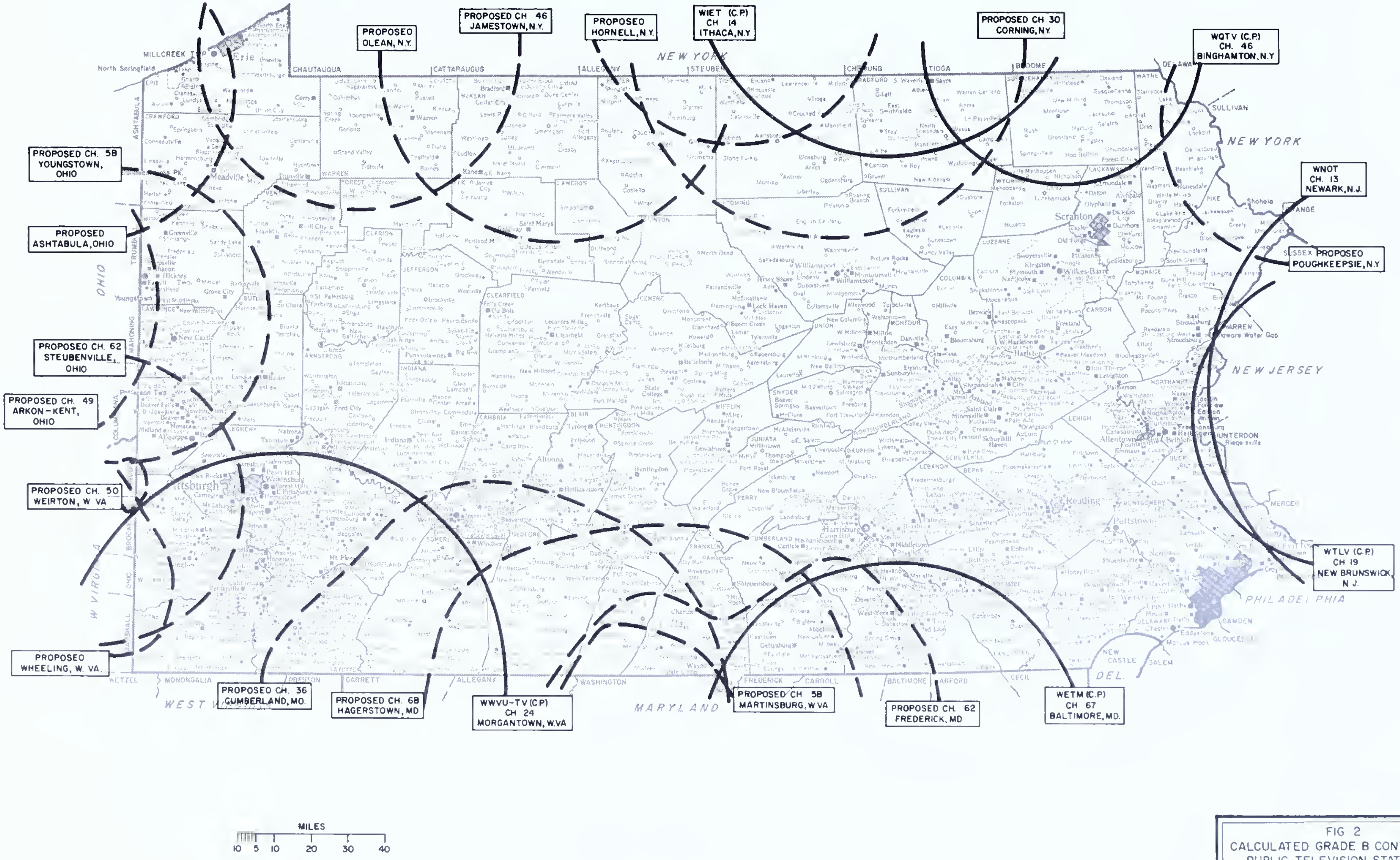

PROPOSED OLEAN, N.Y.
PROPOSED CH 46 JAMESTOWN, N.Y.
PROPOSED HORNELL, N.Y.
WIET (C.P) CH 14 ITHACA, N.Y
PROPOSED CH 30 CORNING, N.Y.
WQTV (C.P) CH. 46 BINGHAMTON, N.Y
WNOT CH. 13 NEWARK, N.J.
PROPOSED POUGHKEEPSIE, N.Y
WTLV (C.P) CH 19 NEW BRUNSWICK N.J.
PROPOSED CH. 58 YOUNGSTOWN, OHIO
PROPOSED ASHTABULA, OHIO
PROPOSED CH. 62 STEUBENVILLE, OHIO
PROPOSED CH. 49 ARKON-KENT, OHIO
PROPOSED CH. 50 WEIRTON, W VA
PROPOSED WHEELING, W. VA.
PROPOSED CH. 36 CUMBERLAND, MD.
PROPOSED CH. 68 HAGERSTOWN, MD
WWVU-TV (C.P) CH 24 MORGANTOWN, W.VA
PROPOSED CH 58 MARTINSBURG, W VA
PROPOSED CH. 62 FREDERICK, MD
WETM (C.P) CH 67 BALTIMORE, MD.
NEW YORK
NEW JERSEY
OHIO
WEST VIRGINIA
MARYLAND
DEL.
PHILADELPHIA
Pittsburgh
Erie
Scranton
Wilkes-Barre
Harrisburg
Reading
Allentown
Altoona
MILES
10 5 10 20 30 40

FIG 2
CALCULATED GRADE B CONTOURS OF PUBLIC TELEVISION STATIONS IN SURROUNDING STATES THAT PROVIDE SERVICE IN PENNSYLVANIA

COMMONWEALTH OF PENNSYLVANIA

12-15-67

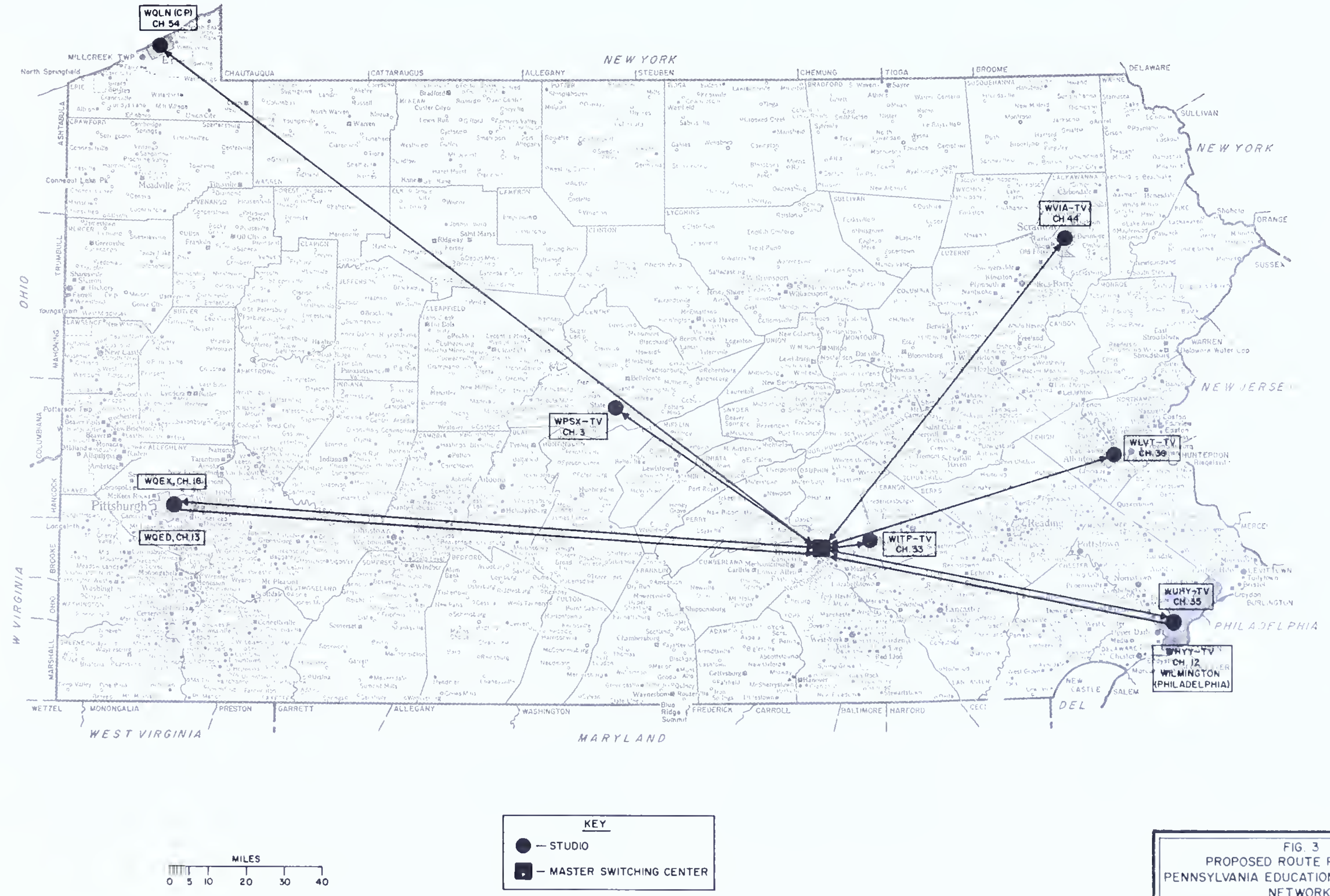


FIG. 3
PROPOSED ROUTE PLAN FOR
PENNSYLVANIA EDUCATIONAL TELEVISION
NETWORK

PLAN A

COMMONWEALTH OF PENNSYLVANIA

11-13-67

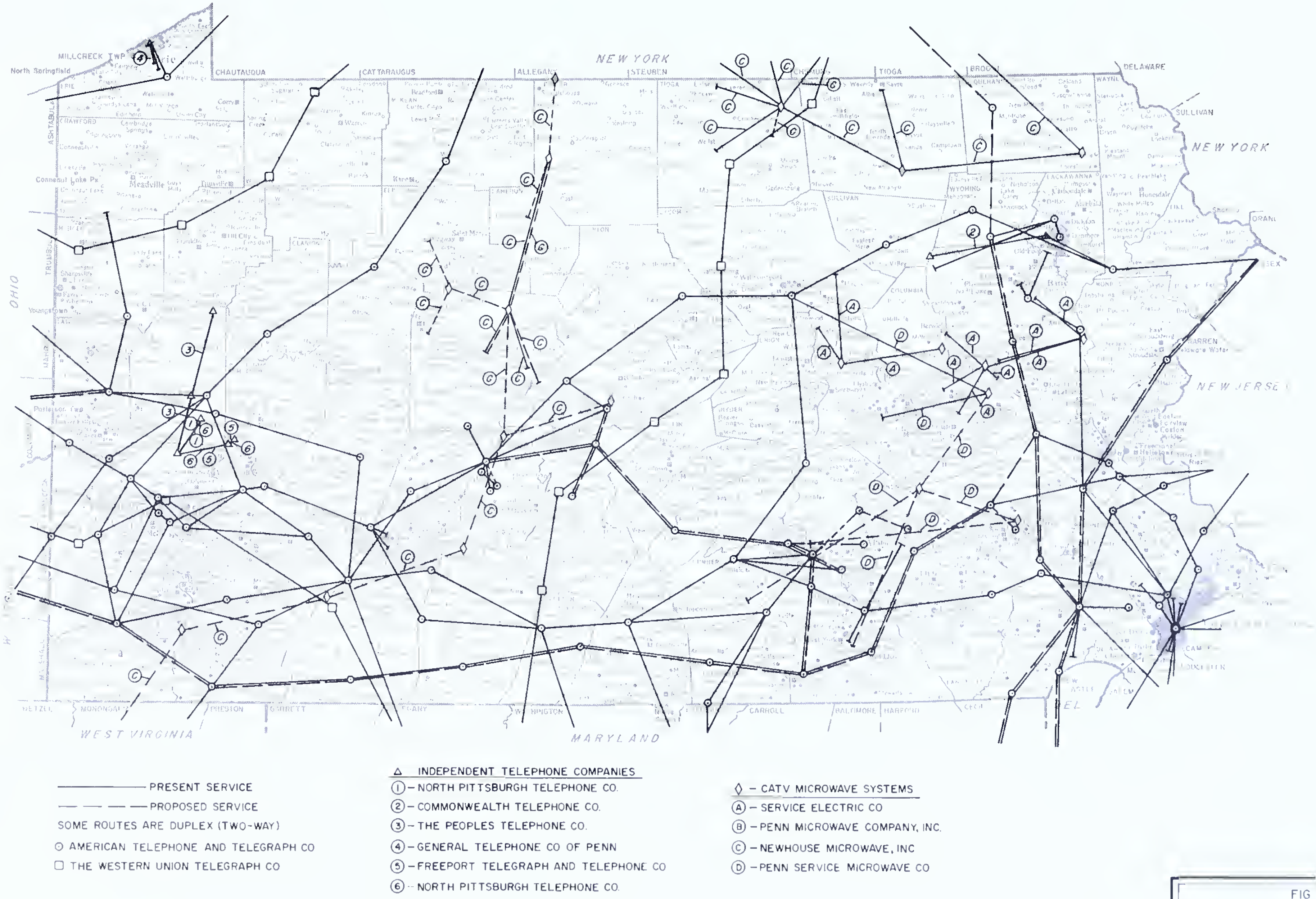

MILLCREEK TWP
North Springfield
CHAUTAUQUA
CATTARAUGUS
ALLEGANY
NEW YORK
STEUBEN
TIOGA
CHEMUNG
BROOME
DELAWARE
SULLIVAN
NEW YORK
ORANGE
NEW JERSEY
ASHTABULA
CRAWFORD
TRUMBULL
Meadville
Conneaut Lake Pk
Youngstown
OHIO
WAYNE
LACKAWANNA
WYOMING
SULLIVAN
COLUMBIA
WARREN
WEST VIRGINIA
MARYLAND
MONONGALIA
PRESTON
GARRETT
ALLEGANY
WASHINGTON
FRANKLIN
CARROLL
BALTIMORE
HARFORD
CECIL
CAMDEN
SALEM
DEL
PRESENT SERVICE
PROPOSED SERVICE
SOME ROUTES ARE DUPLEX (TWO-WAY)
○ AMERICAN TELEPHONE AND TELEGRAPH CO
☐ THE WESTERN UNION TELEGRAPH CO
△ INDEPENDENT TELEPHONE COMPANIES
① – NORTH PITTSBURGH TELEPHONE CO.
② – COMMONWEALTH TELEPHONE CO.
③ – THE PEOPLES TELEPHONE CO.
④ – GENERAL TELEPHONE CO OF PENN
⑤ – FREEPORT TELEGRAPH AND TELEPHONE CO
⑥ – NORTH PITTSBURGH TELEPHONE CO.
◇ – CATV MICROWAVE SYSTEMS
Ⓐ – SERVICE ELECTRIC CO
Ⓑ – PENN MICROWAVE COMPANY, INC.
Ⓒ – NEWHOUSE MICROWAVE, INC
Ⓓ – PENN SERVICE MICROWAVE CO

FIG 4
COMMON CARRIER MICROWAVE SYSTEM IN PENNSYLVANIA

COMMONWEALTH OF PENNSYLVANIA

12-18-67

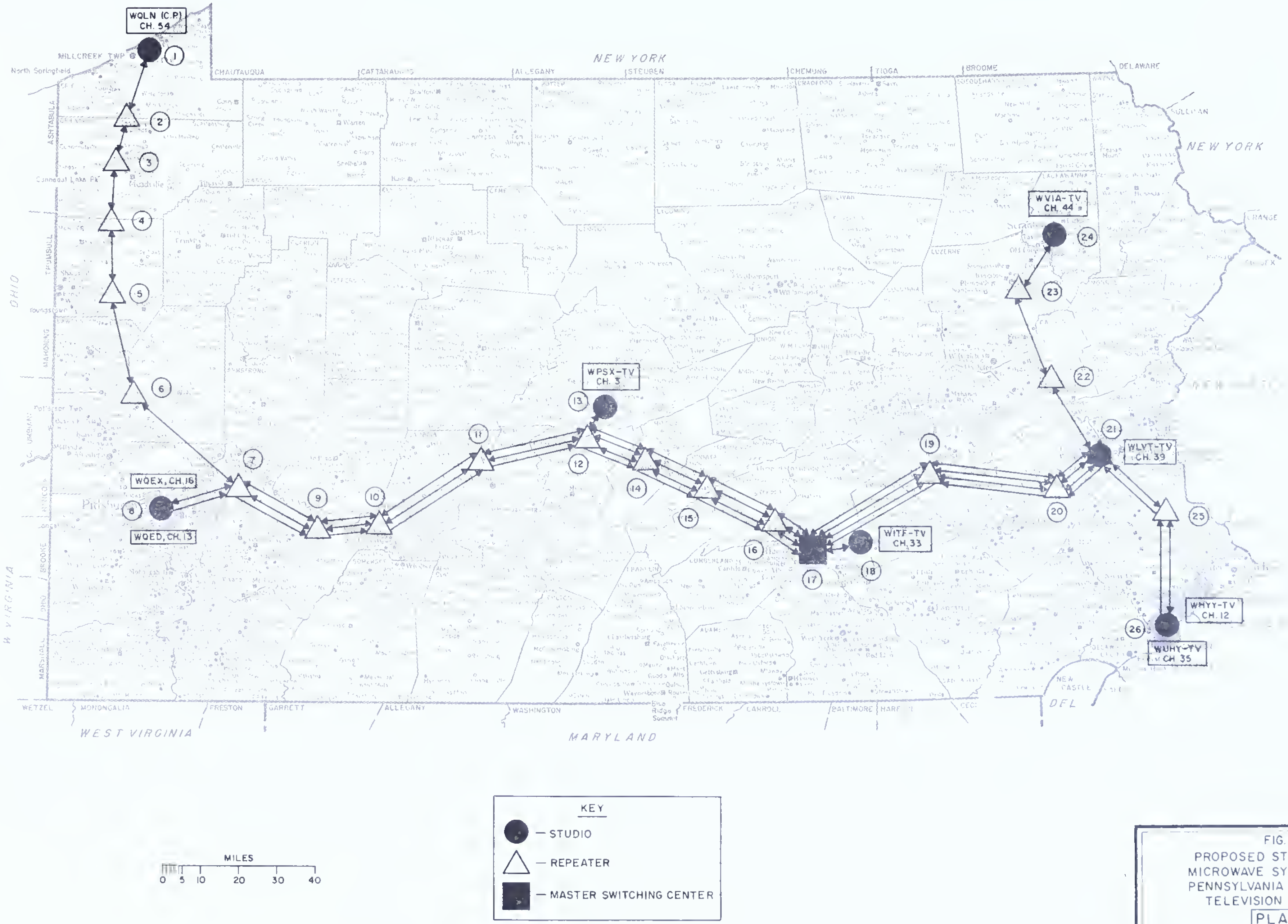


FIG. 5A
PROPOSED STATE-OWNED
MICROWAVE SYSTEM FOR THE
PENNSYLVANIA EDUCATIONAL
TELEVISION NETWORK

PLAN A
DESIGN I

COMMONWEALTH OF PENNSYLVANIA

12-19-67

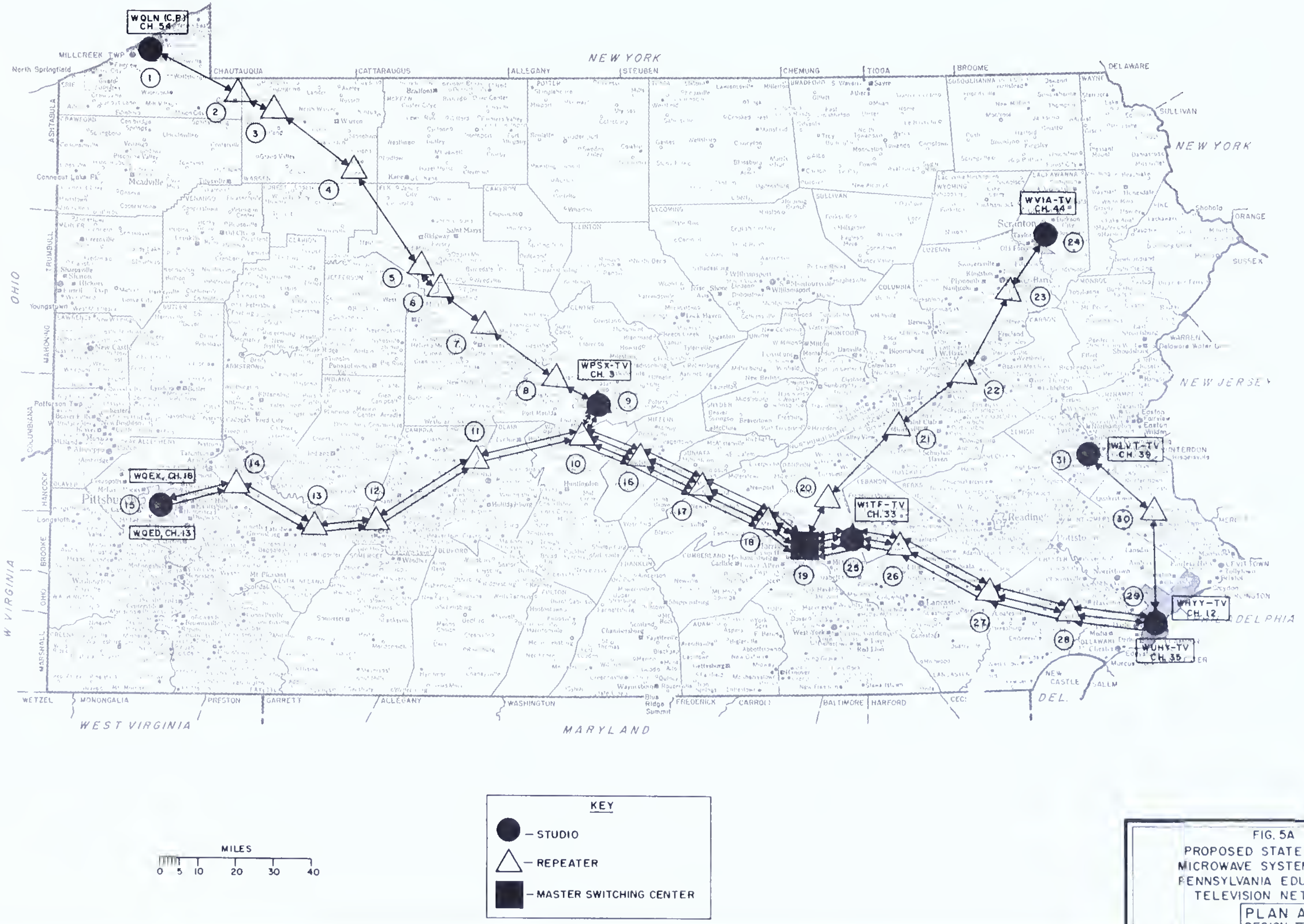


FIG. 5A
PROPOSED STATE-OWNED
MICROWAVE SYSTEM FOR THE
PENNSYLVANIA EDUCATIONAL
TELEVISION NETWORK
PLAN A
DESIGN II
COMMONWEALTH OF PENNSYLVANIA

12-18-67

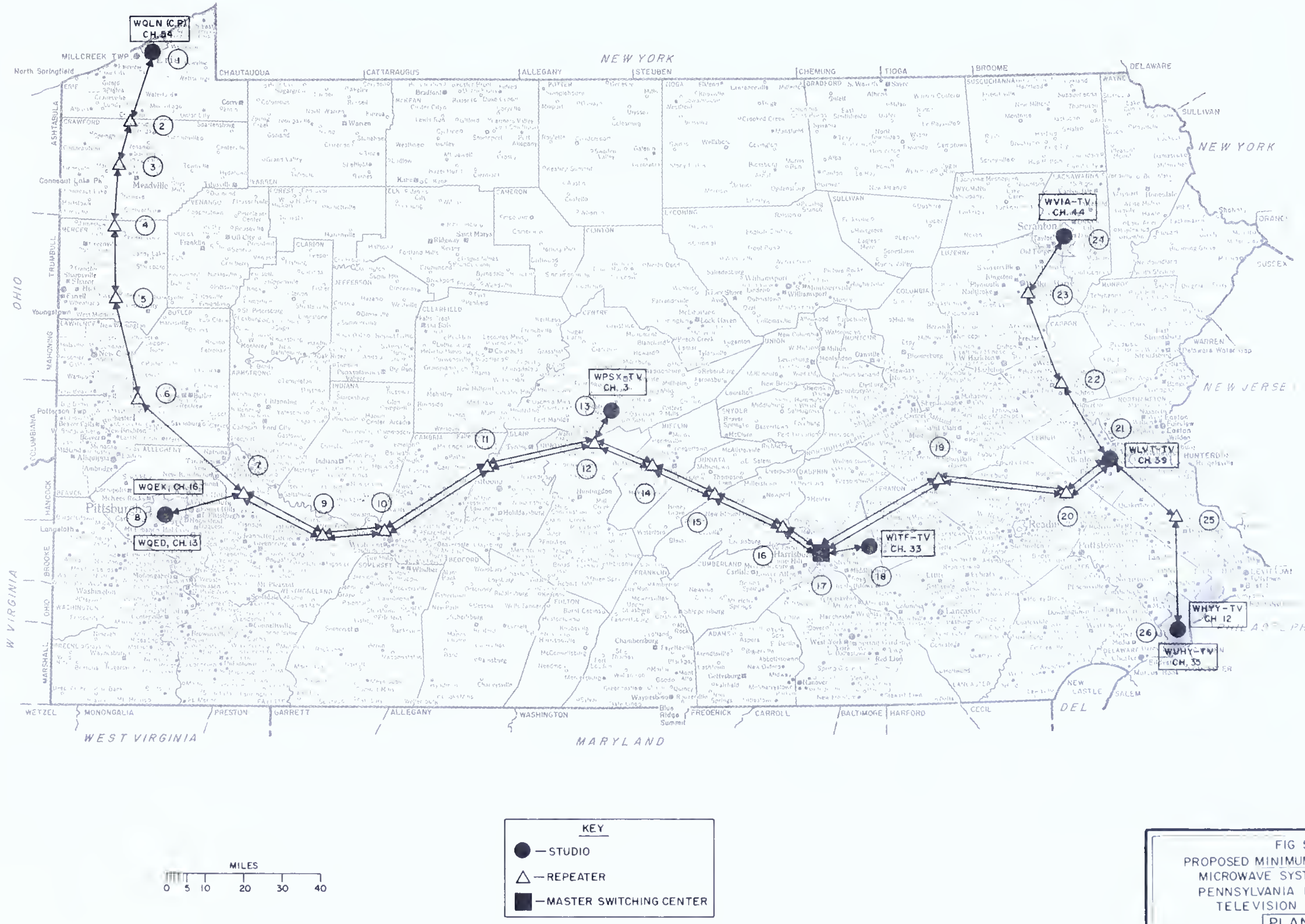


FIG 5B
PROPOSED MINIMUM STATE-OWNED
MICROWAVE SYSTEM FOR THE
PENNSYLVANIA EDUCATIONAL
TELEVISION NETWORK
PLAN B
DESIGN I
COMMONWEALTH OF PENNSYLVANIA

12-20-67

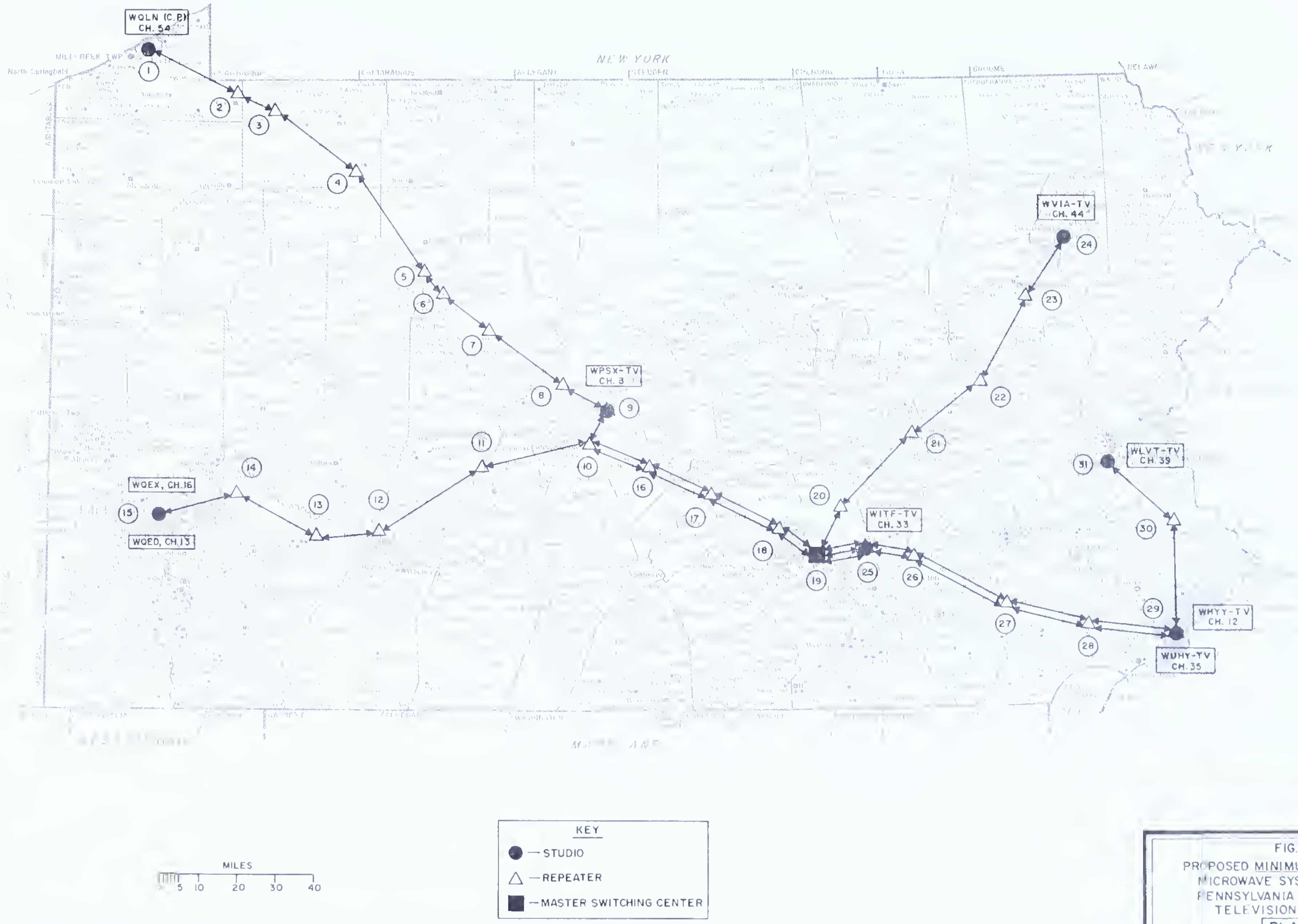


FIG. 5B

PROPOSED MINIMUM STATE-OWNED MICROWAVE SYSTEM FOR THE PENNSYLVANIA EDUCATIONAL TELEVISION NETWORK

PLAN B
DESIGN II

COMMONWEALTH OF PENNSYLVANIA

12-18-67

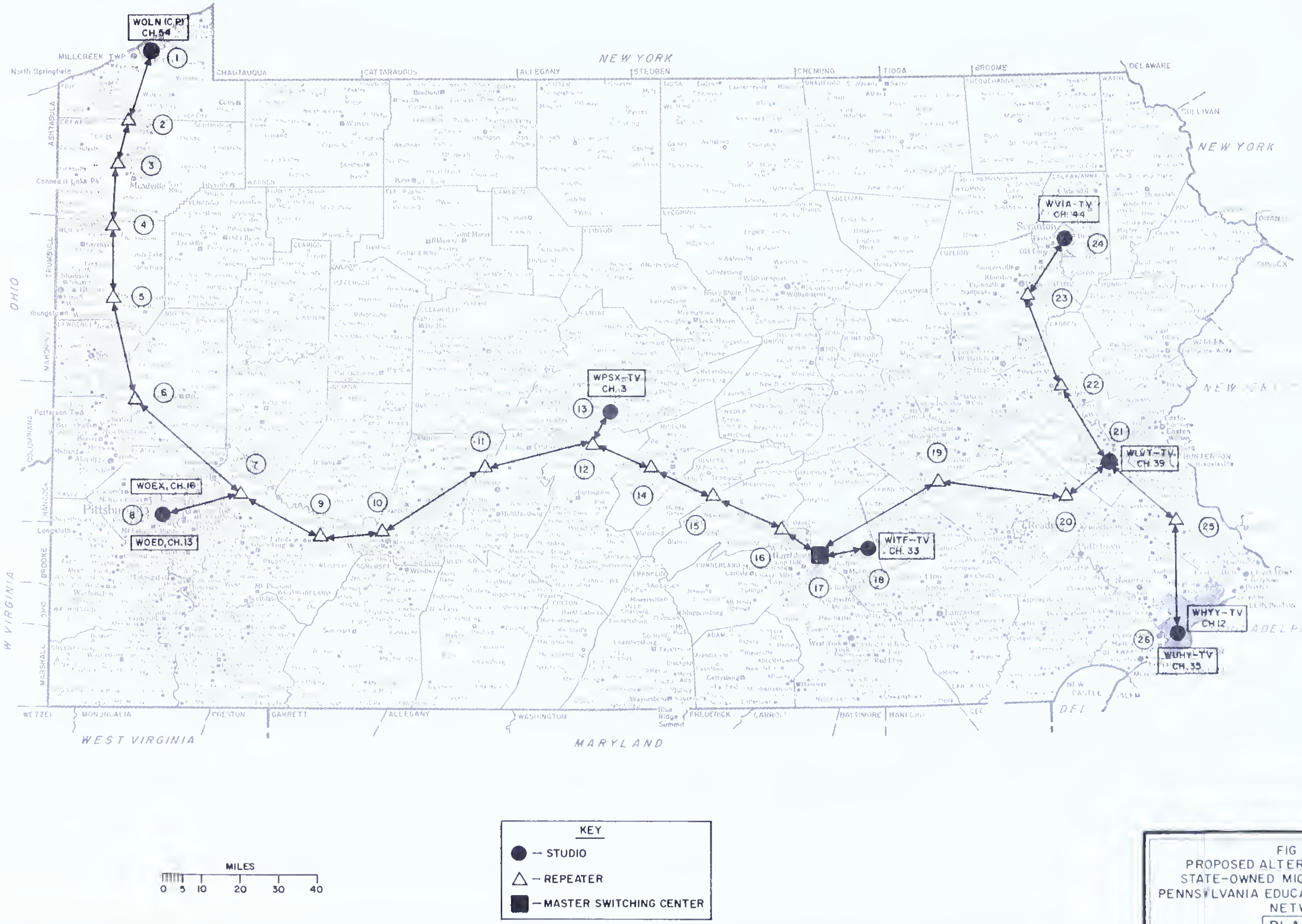


FIG 5C
PROPOSED ALTERNATE MINIMUM
STATE-OWNED MICROWAVE SYSTEM
PENNSYLVANIA EDUCATIONAL TELEVISION
NETWORK
PLAN C
DESIGN I
COMMONWEALTH OF PENNSYLVANIA

12-20-67

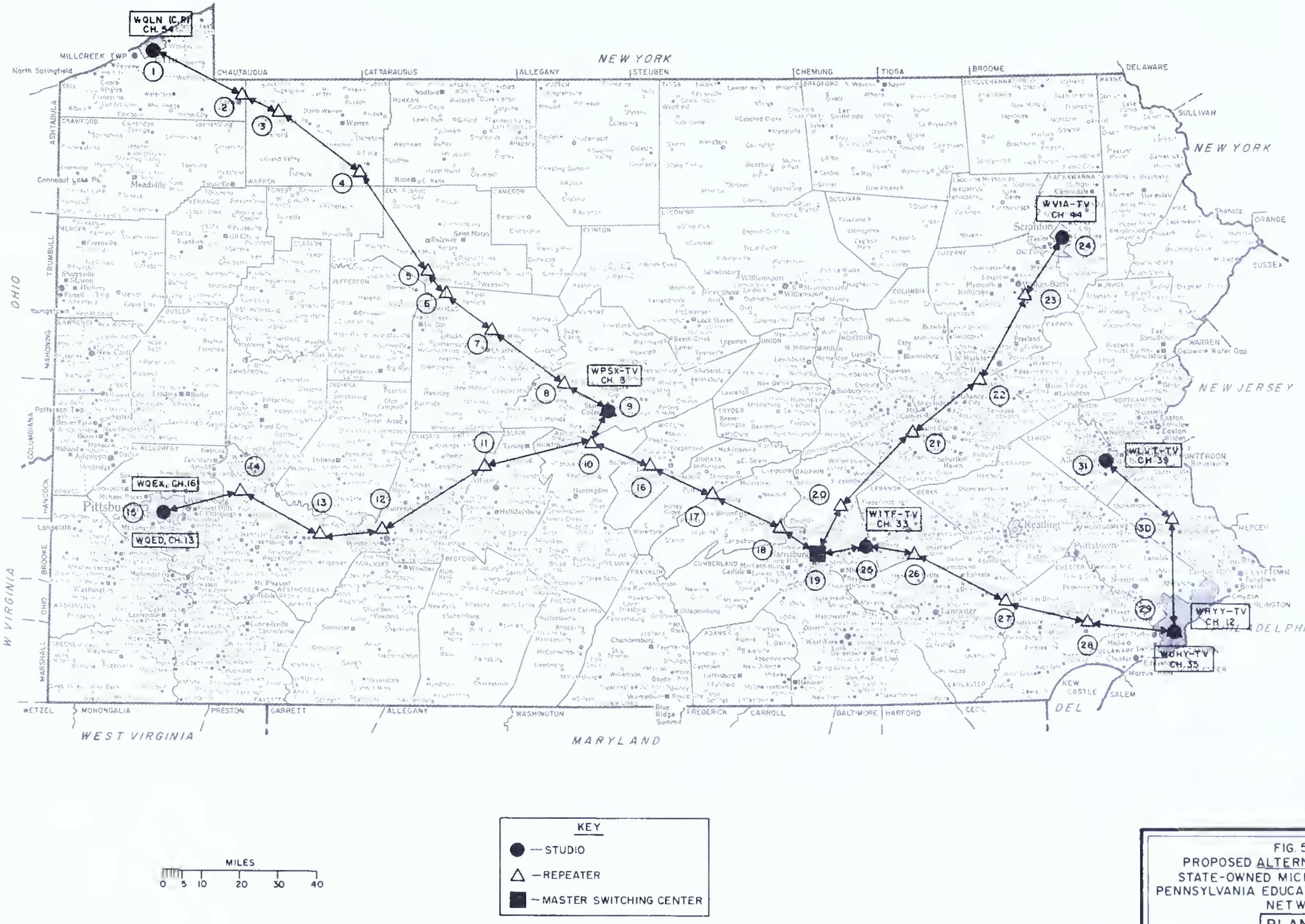


FIG. 5C

PROPOSED ALTERNATE MINIMUM STATE-OWNED MICROWAVE SYSTEM PENNSYLVANIA EDUCATIONAL TELEVISION NETWORK

PLAN C
DESIGN II

COMMONWEALTH OF PENNSYLVANIA

12-19-67

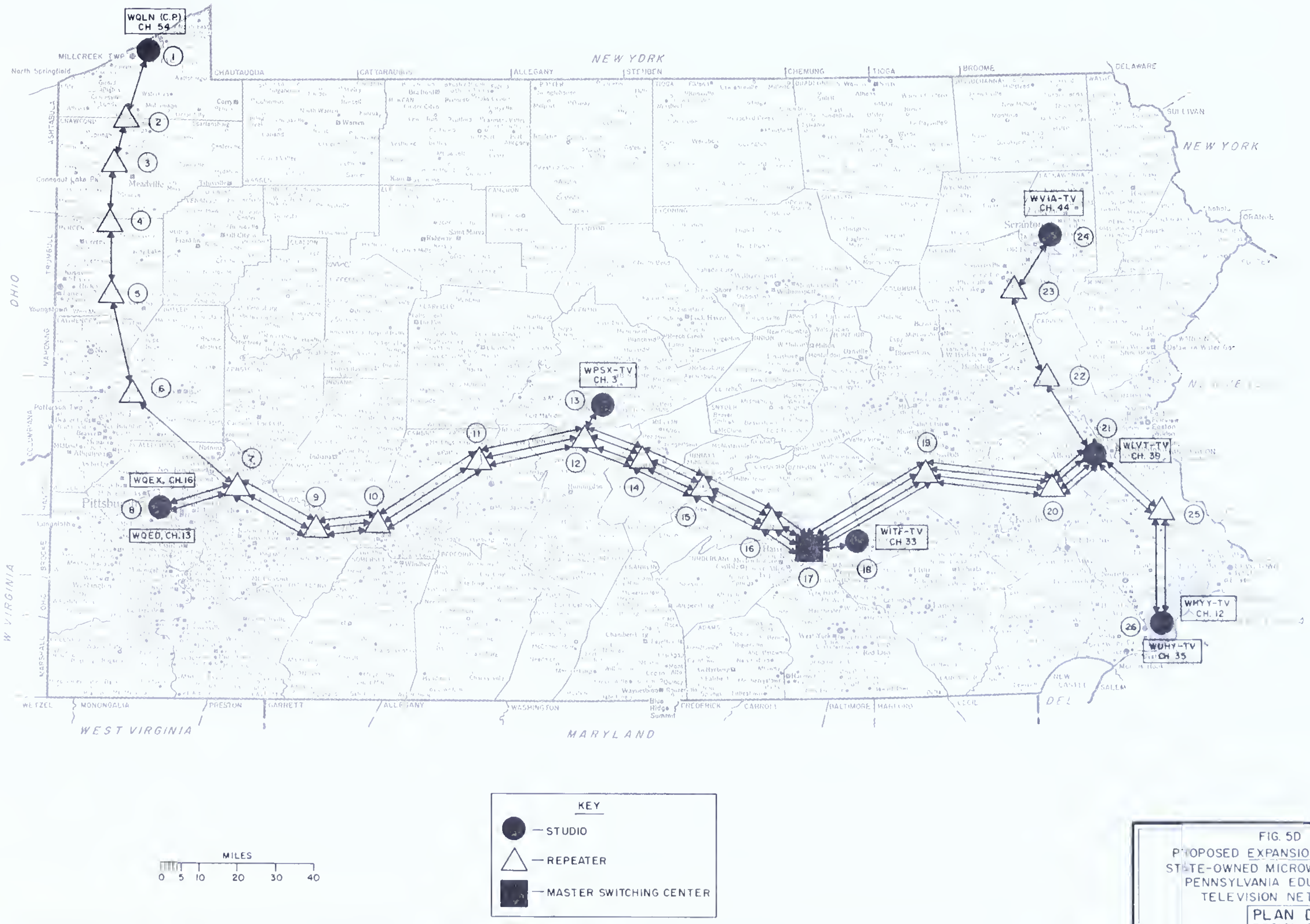
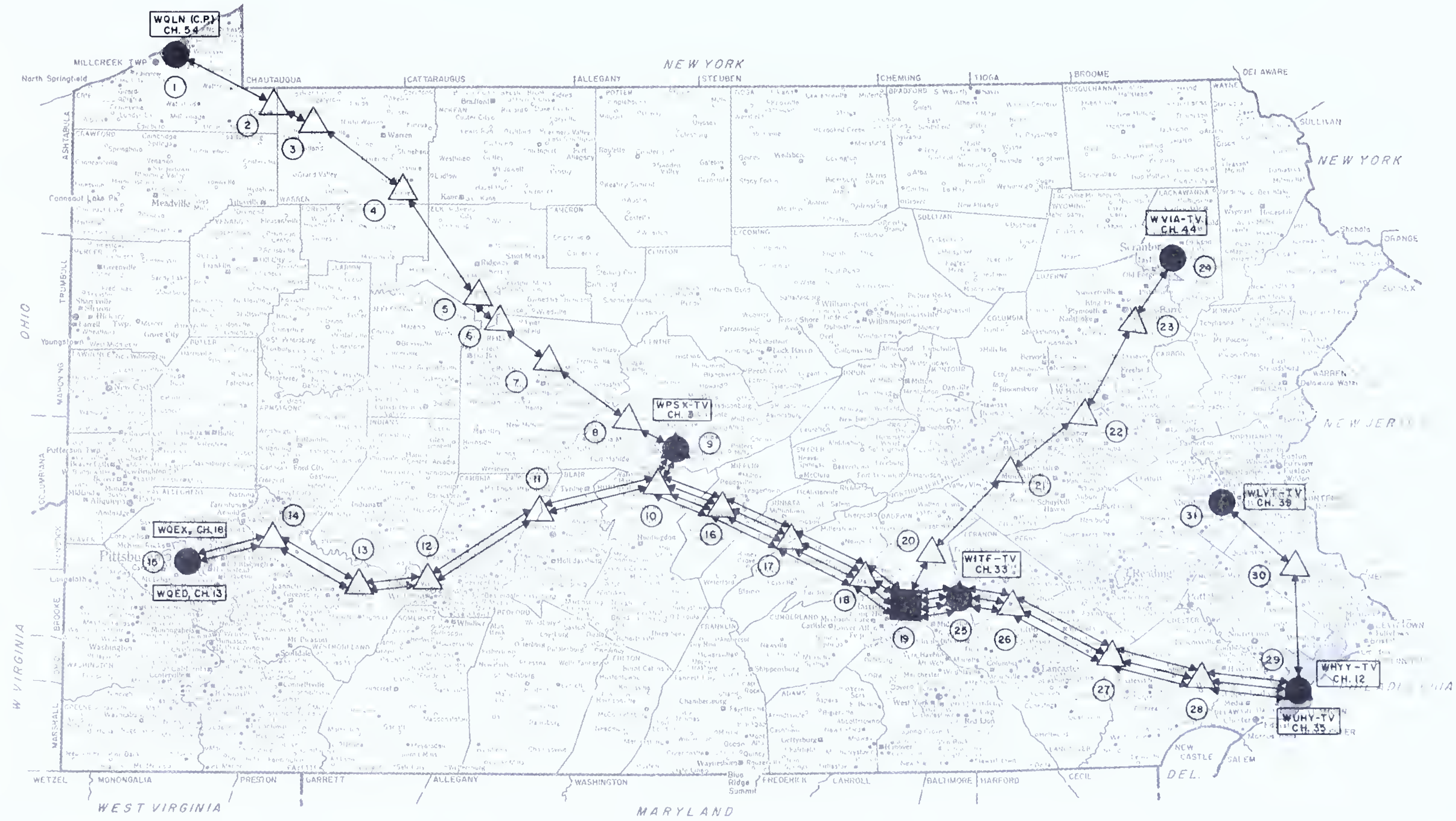


FIG. 5D
PROPOSED EXPANSION OF PLAN A
STATE-OWNED MICROWAVE SYSTEM
PENNSYLVANIA EDUCATIONAL
TELEVISION NETWORK
PLAN D
DESIGN I
COMMONWEALTH OF PENNSYLVANIA

12-21-67



KEY

● — STUDIO

△ — REPEATER

■ — MASTER SWITCHING CENTER

MILES
0 5 10 20 30 40

FIG. 5D

PROPOSED EXPANSION OF PLAN A
STATE-OWNED MICROWAVE SYSTEM
PENNSYLVANIA EDUCATIONAL
TELEVISION NETWORK

PLAN D
DESIGN II

COMMONWEALTH OF PENNSYLVANIA

11-13-67

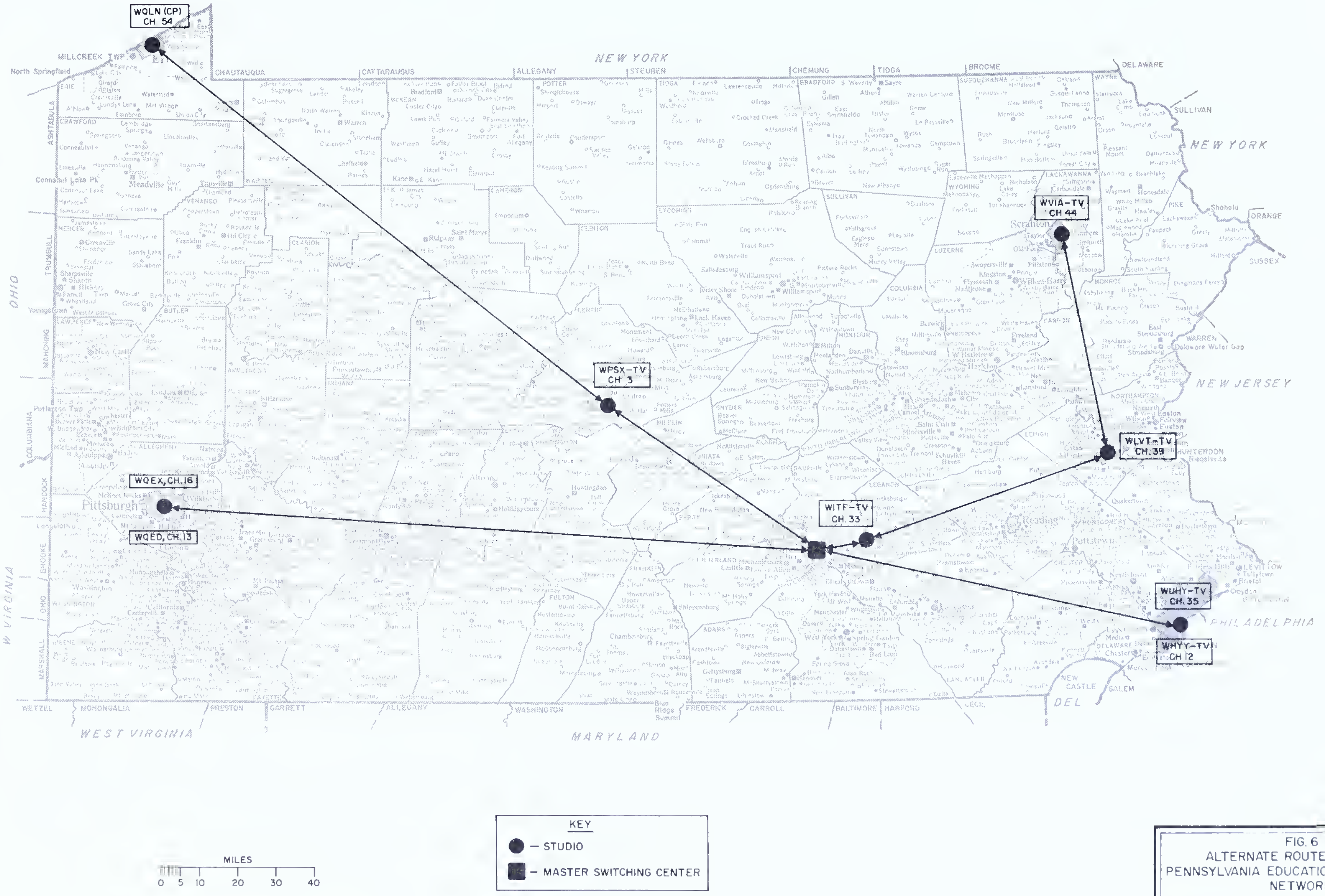


FIG. 6
ALTERNATE ROUTE PLAN FOR PENNSYLVANIA EDUCATIONAL TELEVISION NETWORK

PLAN B

COMMONWEALTH OF PENNSYLVANIA

11-13-67

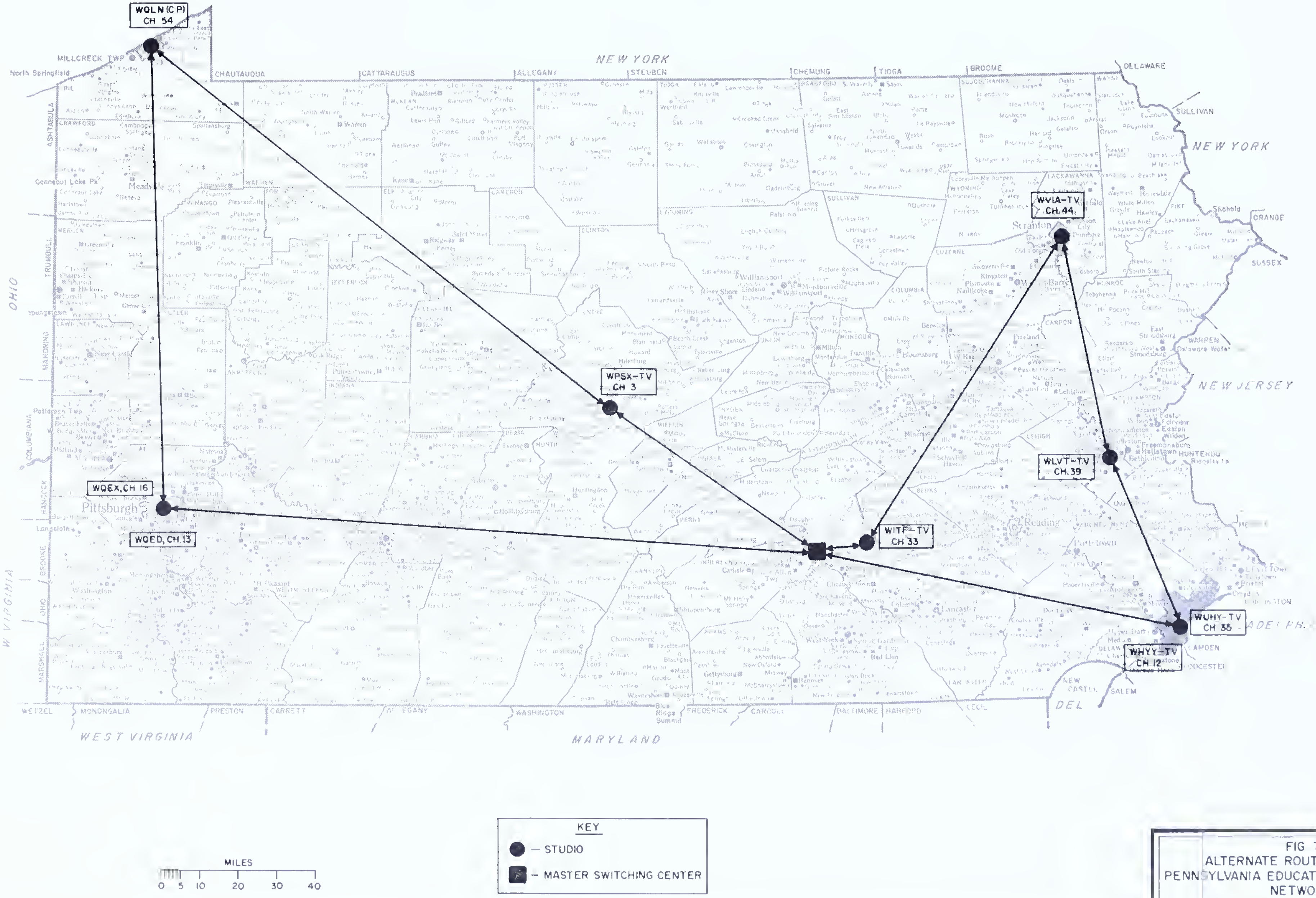


FIG 7
ALTERNATE ROUTE PLAN FOR
PENNSYLVANIA EDUCATIONAL TELEVISION
NETWORK

PLAN C

COMMONWEALTH OF PENNSYLVANIA

12-15-67

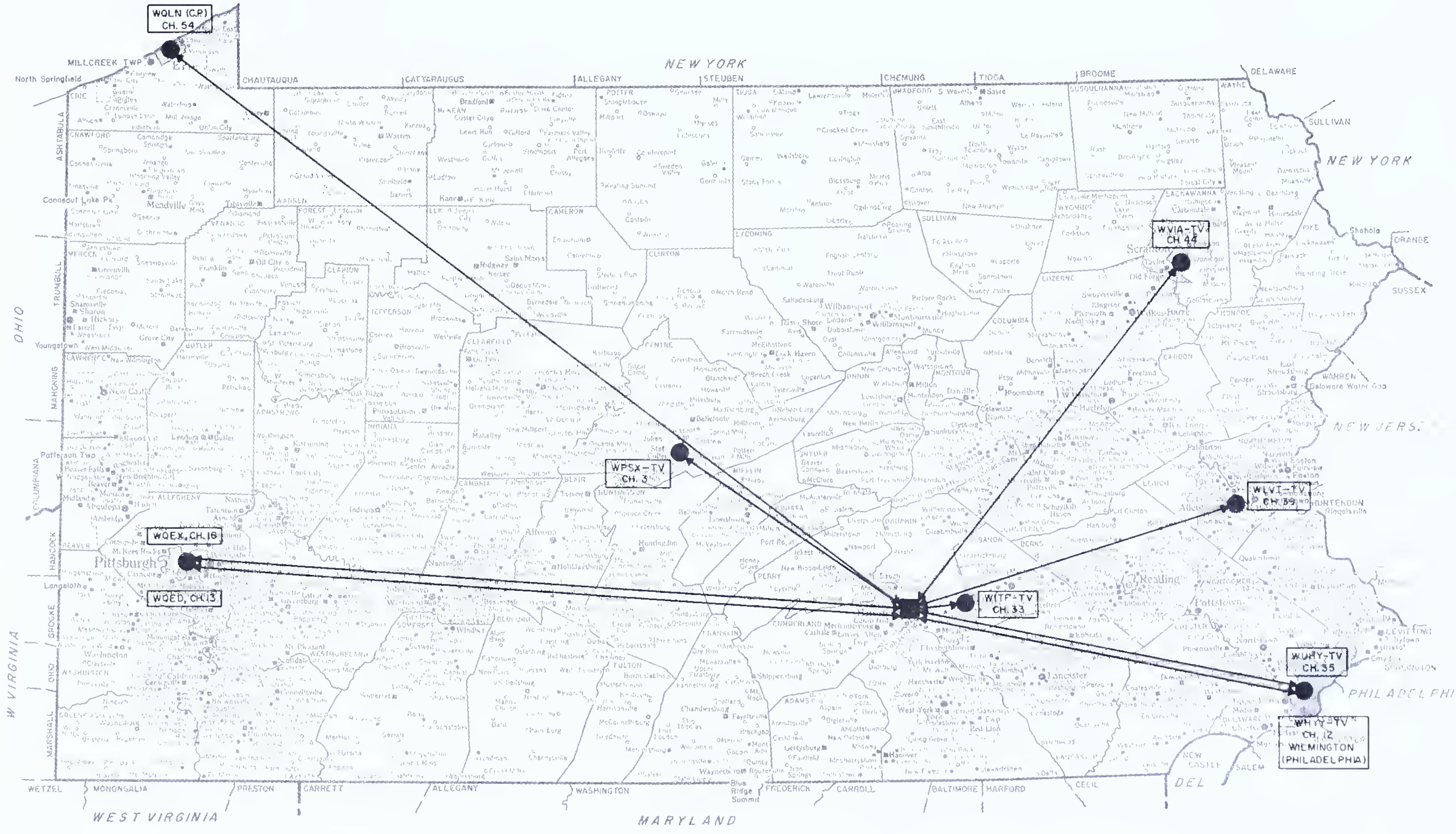


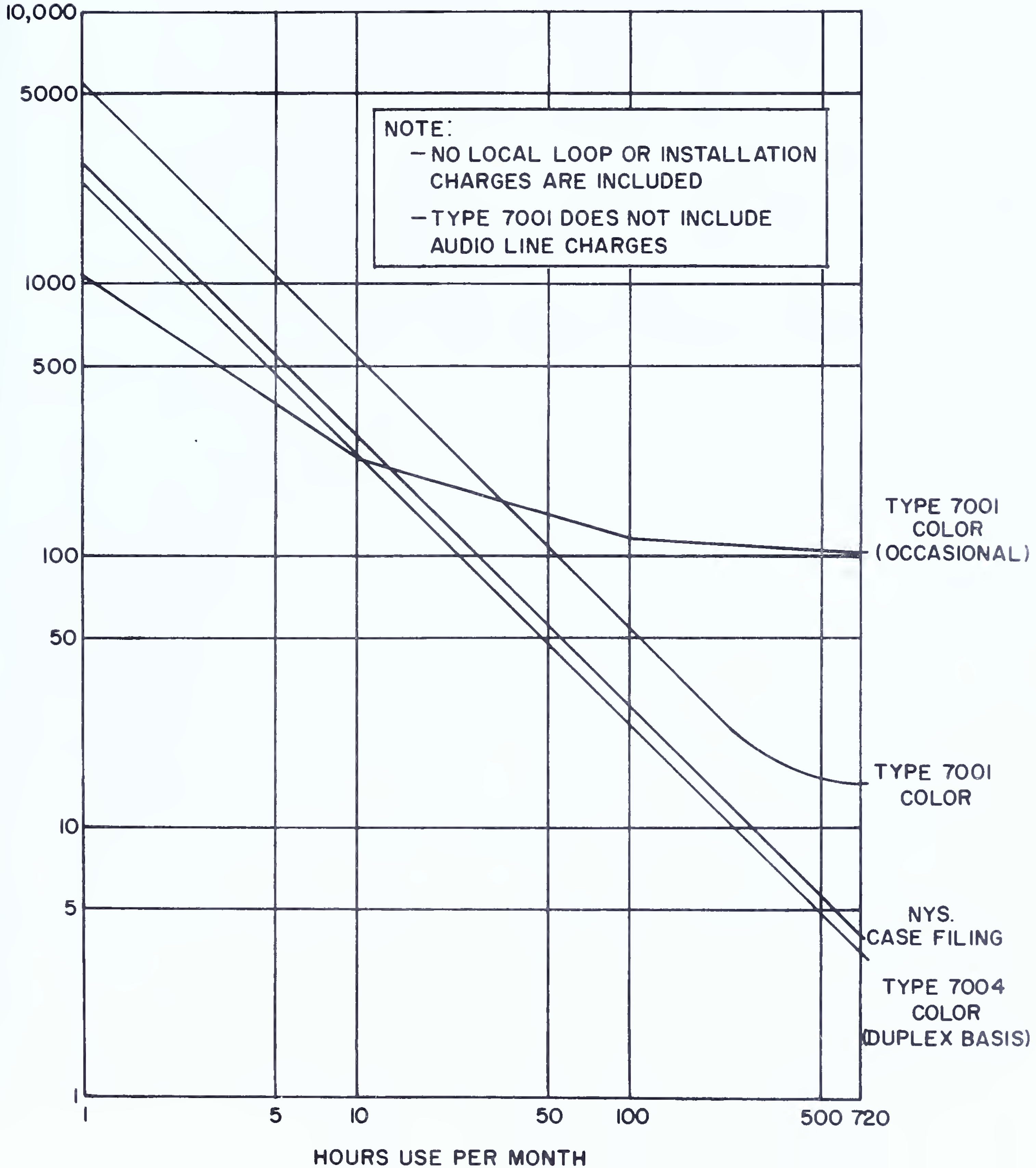
FIG. 8
PROPOSED EXPANSION OF PLAN A
PENNSYLVANIA EDUCATIONAL TELEVISION NETWORK

PLAN D

COMMONWEALTH OF PENNSYLVANIA

12-21-67

FIG. 9
APPROXIMATE RELATIONSHIP
BETWEEN EXISTING TYPES OF SERVICE
TELEVISION TARIFF 260
OF
AMERICAN TELEPHONE AND TELEGRAPH CO.



NOTE:
- NO LOCAL LOOP OR INSTALLATION CHARGES ARE INCLUDED
- TYPE 7001 DOES NOT INCLUDE AUDIO LINE CHARGES

F1201

T BOOKBINDING, INC.
MAY 1973
DDLETOWN, PA.